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PUBLICATION NO. 6

THE ORDOVICIAN SYSTEM IN AUSTRALIA, NEW ZEALAND AND ANTARCTICA

Correlation Chart and Explanatory Notes

by

B. D. Webby, A. H. M. VandenBerg, R. A. Cooper, M. R. Banks, C. F. Burrett,
R. A. Henderson, P. D. Clarkson, C. P. Hughes, J. Laurie, B. Stait
M. R. A. Thomson and G. F. Webers

Compiled and Edited by B. D. Webby

Sponsored by the International Subcommittee on Ordovician Stratigraphy

Reuben J. Ross Jr., Chairman
Stig M. Bergstrom, Secretary
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FOREWORD

This, the third in a projected series of correlation charts of the Ordovician System throughout the world, covers a vast region once incorporated in Gondwana. The many occurrences of Ordovician rocks and fossils are of unusual variety; they range from those that have been intensely studied to those currently being investigated on the frigid frontier of south polar terrain. The several coauthors are all actively engaged in research on and are eminently qualified to write a detailed and timely summary of the present knowledge about these strata. Because previously much of this information has not been readily available to the international audience, this synthesis should be of considerable interest to geologists worldwide.

We offer kudos and thanks to Professor Barry Webby (University of Sydney) not only as a coauthor but especially as the compiler and editor of this very thorough publication. The correlation chart and explanatory notes of Publication No. 6 were prepared in the Department of Geology and Geophysics, University of Sydney, with the assistance of Mr. Len Hay and Miss Sheila Binns.

This publication, and the Ordovician charts for China (Sheng, 1980, IUGS Pub. No. 1) and for the Middle East (Dean, 1980, IUGS Pub. No. 2) are available from the IUGS Secretariat in Paris, France, and from the IUGS Editorial Office in Ottawa, Canada.

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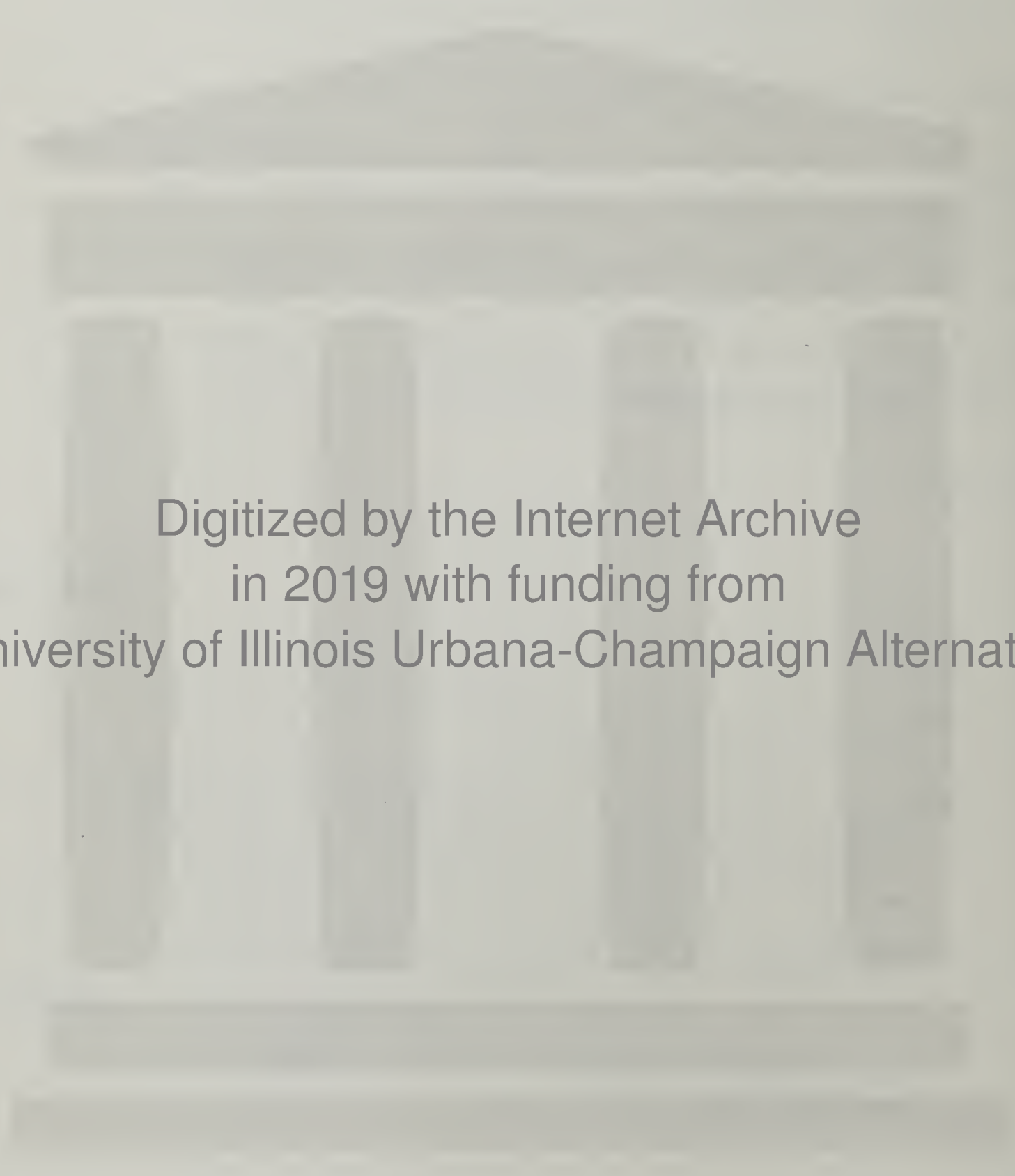
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ABSTRACT

Correlation of the Ordovician formations in Australia, New Zealand and Antarctica is depicted in a sixty-two column chart. Explanatory notes giving such information as age and stratigraphic relationships are included for each stratigraphic unit of the chart. The biostratigraphic framework is outlined, and the evidence for correlations both within the region and with standard Series and Stages overseas. The problems of recognizing Ordovician systemic boundaries are also discussed. A review of evidence for and against the presence of rocks of Ordovician age in the Antarctic is added, together with an extensive, relevant bibliography for the Ordovician System of the region.

1. INTRODUCTION

by B. D. Webby

At meetings of the International Subcommittee on Ordovician Stratigraphy in Columbus, Ohio, in August 1977, it was recommended that a correlation chart of the Ordovician rocks of Australia, New Zealand and Antarctica be compiled, as a part of the Subcommittee's programme of assembling Ordovician correlation charts of the world. Australia, New Zealand and Antarctica have been grouped together based on the widely accepted view that the region had an essential unity during Ordovician times, as a part of Gondwanaland and its south-west Pacific margin.

Knowledge of the distribution of the Ordovician System in Australia, New Zealand and Antarctica has been accumulating rapidly since the early 1950s, in response to various programmes of regional geological mapping by the Geological Surveys, the Universities and other organizations. A good number of the stratigraphic units introduced in Australia are already in need of revision because they have not been defined in accordance with accepted stratigraphic procedures, as outlined in the Australian Code of Stratigraphic Nomenclature (Fourth Edition, 1965).

Unfortunately no complementary rapid increase in the documentation of the faunas and floras of the region has been made. Indeed, there has been nothing in recent times to match the efforts of Hall, Harris, Keble and Thomas, who between 1895 and 1938 (for bibliography, see Keble & Benson, 1939) systematically described the Victorian graptolites and laid the foundations for one of the most comprehensively detailed Ordovician zonal subdivisions. Most groups of fossils, including those which are likely to be most useful for correlation purposes, remain only partly described.

A three-fold division of the Ordovician based on the graptolite succession is currently employed in Australia and New Zealand (Thomas, 1960b; Webby, 1976; Cooper, 1979a). The Lower Ordovician comprises the Lancefieldian, Bendigonian, Chewtonian, Castlemainian and Yapeenian, the Middle Ordovician, the Darriwilian, and the Upper Ordovician, the Gisbornian, Eastonian and Bolindian.

The Ordovician System of Australia comprises the deposits of the cratonic areas (continental platform and shelf margin) in northern, central and western Australia and in Tasmania excepting the north-eastern part (Columns 1-22, Plate 1), and the rocks of the Tasman Geosyncline (including both Lachlan and New England Fold Belts, see Fig. 1) of eastern Australia excepting most of Tasmania (Columns 22-58, Plate 1). The platform and shelf areas are floored by Precambrian basement, and often exhibit intervening Cambrian deposits either conformably or unconformably between the Precambrian and the overlying Ordovician. In the Tasman Geosyncline, on the other hand, the oldest exposed rocks of the 'basement' are typically of Ordovician age. Only in the areas of the Heathcote and Mt. Wellington 'Axes' in Victoria (Thomas *et al.*, 1976) and adjacent to the Peel Fault in north-eastern New South Wales (Cawood, 1976) are proven Cambrian rocks known to underlie the Ordovician.

Platform areas of northern, central and western Australia lack proven Upper Ordovician deposits. Typically the deposits consist of siliciclastics and carbonates, in varying proportions, laid down in shallow epicontinental seas. Short-lived phases of hypersaline conditions occur, as suggested for example by the pseudomorphs of halite in the Lower Ordovician Jinduckin Formation of the Daly River Basin (Column 5) and in the Middle Ordovician Stokes Siltstone of the Amadeus Basin (Column 8). In shelf margin areas of Tasmania and western New South Wales, there is an upward transition from coarse, non-marine, molasse-type conglomerates to shallow marine sandstones and siltstones. On the Tasmanian Shelf the succession continues upward into predominantly shallow water carbonates of Middle to Late Ordovician age. No proven Ordovician volcanics are known from the continental platform, and only one small andesitic intrusion of probable Ordovician age has been reported from the shelf margin of Tasmania (Jago *et al.*, 1977).

In the Tasman Geosyncline, there are two distinctive Ordovician lithological associations. The first comprises 'basinal' quartz-rich sandstones and graptolitic shales,

and the second, which has a more restricted distribution chiefly in New South Wales, consists of 'island arc' intermediate-basic volcanics. Shallow water carbonates accumulated on some of these volcanic piles. The central-west of New South Wales (Columns 44-48) is the only region to exhibit two well-defined, stratigraphically distinct periods of volcanic activity in the Ordovician. The Mt. Windsor Volcanics of the Charters Towers area in east-central Queensland differ from the other associations in being typically of acid-intermediate type.

In New Zealand, Ordovician rocks have been recorded from areas in North-west Nelson and Westland, and Fiordland (Columns 59-61; see also Part 5). Cooper (1979a) has recognized three distinctly different sedimentary belts in North-west Nelson and Westland, each with a different lithological association. The Ordovician of the Central Sedimentary Belt, which comprises a sequence of shallow marine carbonates and mudstones, formed on a Cambrian volcanic and sedimentary pile. To either side of the central belt are non-volcanic, 'trough' associations. In the Western Sedimentary Belt, there is a succession of quartz-rich sandstones and graptolitic shales of Ordovician (Lancefieldian - Gisbornian) age. The Eastern Sedimentary Belt includes thick bodies of limestone and intervening sandstones, siltstones and shales. The main influx of quartz-rich detritus was in Late Ordovician time.

No deposits of proven Ordovician age have yet been recognized in Antarctica (see Part 6). The Ross Orogeny of Antarctica is a correlative of the Delamerian Orogeny in South Australia, which caused the Adelaide Geosyncline and Kanmantoo Trough to be uplifted, folded, regionally metamorphosed and locally intruded by granites (Thomson, 1969). The 'Delamerian' granites and metamorphics have a range of radiometric ages from 515 to 430 m.y. (i.e., from Late Cambrian to Late Ordovician), with a peak about 480-470 m.y. (Webby, 1978, p.45).

The assistance of Mr. Len Hay (Sydney University) in drafting the correlation chart and other illustrations is gratefully acknowledged.

2. SUBDIVISION AND CORRELATION OF ORDOVICIAN SUCCESSIONS

A. Victorian stages and graptolite zones (A. H. M. VandenBerg)

(i) Lower Ordovician (Lancefieldian, Bendigonian, Chewtonian, Castlemainian and Yapeenian) and Middle Ordovician (Darriwilian)

In the detailed mapping of the goldfields of Castlemaine, Bendigo, Steiglitz and Daylesford around the turn of the century, it soon became apparent that the monotonous lithology and close folding of the rocks made lithological subdivision impracticable. Instead, the rocks were subdivided from the beginning into biostratigraphic units based on their graptolite faunas. Hall (1895, 1899b, 1912, 1914) subdivided a substantial portion of the Lower Ordovician into stages (or 'series', as they are known in the Victorian literature) and zones, and his scheme was gradually refined and extended by Harris (1916, 1933, 1935), Harris & Keble (1932), Harris & Thomas (1938c), and Thomas (1960b).

Because of the widespread distribution of almost all zones, little attempt was made to establish the faunal succession in any single stratigraphic section. Rather, the zonal scheme was used primarily as a mapping tool to reveal the complex structure of the goldfield areas. As a consequence, only Zones La1, La1.5, La2 and Da4 have firmly fixed type localities. Harris & Keble (1932) listed 'typical localities' for the other zones, but almost all of these are without stratigraphic or faunal documentation.

The subdivision and zone definitions adopted here (Fig. 2; Plate 1) differ slightly from those of Harris & Thomas (1938c) - the only significant changes are the addition of Zone La1.5, deletion of Zone Ch3, and substitution of Zone Ya3 for Ya2b, with a change in definition. Most of the zone boundaries are defined by the appearance or disappearance of one or two key species, which are usually found in great abundance. The exceptions are Zones La1 and La1.5, both of which are confined to very thin bands in an otherwise unfossiliferous section, and the boundaries between Zones Da1, Da2, and Da3, which are best interpreted as boundaries between the acme-zones of their key species (Harris 1935, p. 328; Harris & Thomas, 1938c). The nature of the Da3-Da4 boundary is not known since these zones have not been found together in any single section.

Lancefieldian. The Stage is defined as the interval between the appearance of Dictyonema scitulum and Anisograptus at the base, and of Tetragraptus fruticosus at the top. The fauna consists of Dictyonema spp. and anisograptids, with dichograptids (Tetragraptus spp.) appearing in the top two zones.

The La1 Zone of D. scitulum and Anisograptus was originally known as the Zone of Dictyonema campanulatum, D. scitulum and Staurograptus diffissus (Harris & Keble, 1932). Revision of type fauna by Cooper & Stewart (1979) has shown that D. campanulatum is in part conspecific with D. scitulum, and that S. diffissus comprises two new species of

Anisograptus. The fauna is restricted to a band about 140 mm thick in the Stauro Gully Shale and is known from only two localities at Lancefield.

The La1.5 Zone of Psigraptus was introduced by Cooper & Stewart (1979) for a newly discovered fauna, comprising Psigraptus lenzi, Clonograptus spp., and Adelograptus sp., in the Bryo Gully Shale at Lancefield. The fauna is restricted to a band less than 30 mm thick, about 140 m stratigraphically above the type La1 locality and about 90 m below the appearance of La2 forms (VandenBerg & Wilkinson, in prep.). It is not known from outside its type locality.

The type locality of the La2 Zone of Adelograptus victoriae is the Lancefield Quarry (Hall 1899a; see also Thomas 1960a, in which it is erroneously marked La3). It is situated either in topmost Bryo Gully Shale or basal Angry Hill Sandstone (VandenBerg & Wilkinson, in prep.). The fauna is diverse, comprising Dictyonema pulchellum, D. macgillivrayi, Adelograptus victoriae, A. sp., Kiaerograptus antiquus, K. pritchardi, K. taylori, Clonograptus magnificus, C. rigidus, C. tenellus, C. flexilis, Temnograptus sp., and the earliest dichograptids, Tetragraptus decipiens and T. bulmani (Hall, 1899a; Berry, 1966; Cooper & Stewart, 1979).

The La3 Zone of Tetragraptus approximatus is marked by the presence of T. approximatus and T. acclinans, and also contains the earliest didymograptids, D. extensus and D. similis. Many La2 forms, including A. victoriae, persist into the zone. The 'typical locality' listed in Harris & Keble (1932) is Bull Dog Creek, Mornington Peninsula, but its fauna is not documented. At Lancefield, the La3 fauna is limited to the top of the Angry Hill Sandstone.

The lower two zones of the Lancefieldian are only known from their strata typica at Lancefield, but the upper two are widely distributed, especially in the Bendigo Sedimentary Belt, and are also recorded from the Heathcote Belt and Mornington Peninsula. Zone La2 has been recorded also from the Howqua Shale at Howqua River, and Zone La3 occurs at Phosphate Hill near Mansfield and at Boolarra near Morwell.

Bendigonian. The Stage is defined as the interval between the appearance of Tetragraptus fruticosus at the base, and of Didymograptus protobifidus at the top. Tetragraptus fruticosus is the most common species, and is accompanied by a very diverse dichograptid fauna - ten form genera are represented even if Tetragraptus and Didymograptus are interpreted in the broad sense used by Bulman (1970) - and by a few anisograptids. The faunal lists given by Thomas (1960b) give the impression that the fauna of the lower Bendigonian is much more diverse than the upper, but this is because the Be1 and Be2 beds at Campbelltown have been sampled much more carefully, and are better documented, than any other Bendigonian locality (Harris & Thomas, 1938a, 1939, 1940, 1948).

The zonal boundaries of Zones Be1, Be2 and Be3 (Fig. 2) are unchanged from Harris & Thomas (1938c). The Be4 Zone of T. fruticosus (3-br.) was defined by them as a zone in which only the three-branched subspecies of T. fruticosus is present. However, rare specimens of the 4-branched subspecies are now known to occur as high as Zone Ch1. While the distinction between Zones Be3 and Be4 is still valid, they probably need to be redefined in terms of relative abundance of the two subspecies of T. fruticosus. It might be mentioned that many localities have in the past been assigned to Zone Be4 from very small collections, sometimes of no more than two or three specimens.

Bendigonian rocks are widely distributed in the Bendigo Sedimentary Belt and occur also in the Heathcote Belt, on Mornington Peninsula, and along the upper Howqua River. The 'typical localities' listed by Harris & Keble (1932) are Hustler's Hill (Be1), Garden Gully (Be2), Red White & Blue Reef (Be3) and Napoleon Syncline (Be4), all at Bendigo. None have documented faunas.

Chewtonian. The Stage is defined by the appearance of Didymograptus protobifidus at the base and of Isograptus victoriae lunatus at the top; the latter approximately coincides with the disappearance of D. protobifidus. The fauna consists almost entirely of dichograptids, with isograptids appearing in the upper zone. Didymograptus protobifidus is abundant throughout the stage.

The classic subdivision of the Chewtonian is based on the presence (in Zone Ch1) or absence (in Ch2) of T. fruticosus (Harris, 1916, 1933; Harris & Keble, 1932). Harris (1935) introduced a new name, the 'Zone of D. proto-bifidus and I. caduceus var. primula and lunata' for Ch2 (then C5). Harris & Thomas (1938c) reverted to the classical subdivision in their table, but in their text Zone Ch2 was described as 'Beds with D. protobifidus and usually I. caduceus var. primula and possibly I. caduceus var. lunata (T. fruticosus absent or very rare)'. They also introduced a new Ch3 Zone of Didymograptus balticus for a 'pathological horizon' with 'Didymograpti of the type of D. balticus', together with small forms of 'I. caduceus var. lunata'. Thomas (1960b) made no mention of Zone Ch3, and again

reverted to the original definition of Zone Ch2. The presence of I. victoriae lunatus in 'Ch3' suggests to the writer (A.H.M.V.) that it is part of Zone Ca1, not Ch2 as was argued by Beavis (1975).

Chewtonian rocks are widely distributed in the Bendigo Sedimentary Belt. They occur also on Mornington Peninsula and in the Heathcote Belt. Harris & Keble (1932) listed Paddy's Gully, Bendigo (Ch1) and Wattle Gully, Chewton (Ch2) as 'typical localities'.

Castlemainian. The Stage is defined as the interval between the appearance of Isograptus victoriae lunatus at the base, and Oncograptus at the top. The fauna is dominated by the Isograptidae, and is marked by the upward increase in size of Isograptus victoriae. The remainder of the fauna consists almost entirely of dichograptids, with Clonograptus as the sole remaining anisograptid.

Modern subdivision of the Castlemainian was informally introduced by Harris (1933, 1935); more formal definitions were given by Thomas (1960b). The stratigraphic validity of the Victorian subdivision was proved by Cooper (1973), who approached the classification of Isograptus victoriae from a population concept and gave much shorter ranges for key subspecies than Thomas (1960b). Within Victoria, Zones Ca1 and Ca2 are virtually undocumented, and no work has yet been done to test the subdivision using Cooper's approach.

Castlemainian rocks are widely distributed in the eastern part of the Bendigo Sedimentary Belt, east of the Muckleford Fault, and have also been recorded from the Heathcote Belt, from Mornington Peninsula, and from a small, little-known outcrop near Dookie. The 'typical localities' listed by Harris & Keble (1932) are east of Victoria Gully (Ca1), Victoria Gully (Ca2) and McKenzie's Hill Water Race (Ca3), all at Castlemaine.

Yapeenian. The Stage is defined as the interval between the appearance of Oncograptus at the base, and Glyptograptus austrodentatus at the top. Apart from the three zonal index genera, the stage contains abundant other isograptids such as Isograptus, Pseudisograptus, Skiagraptus and Maeandrograptus. The remainder of the fauna is comprised of the dichograptid genera Dichograptus, Tetragraptus, Goniograptus, Phyllograptus, and Didymograptus. Pseudotrigraptus ensiformis and Didymograptus v-deflexus both appear at the base and are very abundant.

The definitions of the lower two of the three zones introduced by Harris (1916) remain unaltered. The upper zone, originally known as the 'D3 Zone of Cardiograptus morsus and Trigraptus without Oncograptus' (Harris, 1916) was relegated to subzonal status (Ya2b) by Harris & Thomas (1938c) and deleted altogether by Thomas (1960b). Beavis (1975) resurrected the Ya2b subzonal connotation but in a different sense, based on misinterpretation of the D5-D4 [Ya1-Ya2] 'passage beds' subzone of Ripper (1932) which, if accepted, would form an upper subzone of Zone Ya1. The Ya3 Zone of Apiograptus, introduced by McLaurin (1976), is recognised by the presence of Apiograptus and thus differs from Ya2b of other authors. Its fauna includes Apiograptus crudus, A. crudus gisbornensis, a narrow form of Cardiograptus morsus, and rare Oncograptus biangulatus.

Yapeenian rocks are widespread in the eastern part of the Bendigo Sedimentary Belt and have also been recorded from the Heathcote Belt and Mornington Peninsula. The 'typical localities' listed by Harris & Keble (1932) are on the Castlemaine-Walmer Road east of the borough boundary, Castlemaine (Ya1), and Chinamen's Creek, Muckleford (Ya2). The best-documented Ya3 section is also at Chinamen's Creek (McLaurin, 1976). Good faunal lists have also been published for Loc. Ba 71 (Ya1), Willey's Quarry (Ya2) and Loc. 24, Jackson Creek (Ya3), in the Gisborne area (McLaurin, 1976).

Darriwilian. The subdivision of the Lower Ordovician introduced by Hall (1899b) left a large gap between the 'Castlemaine series' and the 'Darriwil Series'. Five graptolite zones were subsequently recognised in this gap by Harris (1916, 1933, 1935), who originally intended to introduce a new 'Yapeen Series' for the lower three zones (Harris, 1916, p.57) but changed his mind because of their occurrence at Darriwil. Instead, he extended the 'Darriwil Series' downwards to cover the whole interval. At that time, the Ordovician was still subdivided into two parts, Lower and Upper, with the boundary placed at the modern Da3-Da4 Zone boundary (then the top of the 'Darriwil Series') (Thomas, 1935). Harris & Thomas (1938c) felt that the Darriwilian had no longer any definite meaning and advocated that it be dropped altogether. They resurrected the Yapeenian for the lower part, and introduced the term Middle Ordovician for the upper three zones, plus the Zone of G. teretiusculus which until then had been part of the Gisbornian. They ignored their own advice in subsequent papers (e.g. Thomas, 1960b) and used the term Darriwilian interchangeably with Middle Ordovician.

The base of the Darriwilian Stage is defined by the appearance of Glyptograptus austrodentatus, and the top is provisionally placed at the level at which leptograptids first

appear (see below). The stage has a rich and very diverse fauna, dominated by diplograptids, and also marks the first appearance of glossograptids, cryptograptids and retiolitids. Sinograptids are restricted within it. Isograptids and all but two species of dichograptids disappear at the top.

The four standard zones of Harris & Thomas (1938c) were slightly amended from Harris (1935) - the Zone of Didymograptus nodosus became the Zone of Diplograptus decoratus, and the Zone of Diplograptus (Glyptograptus) euglyphus was relegated to subzonal status and incorporated in the Zone of D. (G.) teretiusculus. The zonal boundaries between Da1, Da2 and Da3 were defined not by the appearance or disappearance of their index species but by their relative abundance (Harris, 1935; Harris & Thomas, 1935, 1938c). In practice, this has given much difficulty in determining to which zone a particular assemblage might belong, since the relative abundance of key species is rarely recorded. The Da3-Da4 boundary is not clearly defined - the two zones have not yet been found in any single section. Apart from the index species, the Darriwilian contains a number of other important and stratigraphically restricted forms, whose approximate ranges are shown in Fig. 2.

Darriwilian rocks of the lower three stages are widespread in the eastern part of the Bendigo Sedimentary Belt. A full sequence is present in the Gisborne region, but the Da4 type locality is isolated from the other zones. Faunas belonging to Zones Da3 and Da4 are known from several Mount Easton Shale localities in the Mount Easton Province and along the Mount Wellington Belt, e.g., at Howqua River (Harris & Thomas, 1938b), and at Waratah Bay. Poorly documented Darriwilian faunas also occur along the Heathcote Belt at Heathcote, and on Mornington Peninsula. The oldest faunas in the Tabberabbera Belt are Da2 or Da3.

Harris (1935) listed a number of 'typical localities' for the lower three zones, all from Bendigo East. The type locality of Zone Da4 is Loc. Ba67, at the junction of Riddell and Jackson Creeks, near Gisborne (Harris, 1935).

(ii) Upper Ordovician (Gisbornian, Eastonian and Bolindian)

Subdivision of the Upper Ordovician differs in several important aspects from that of the Lower and Middle Ordovician. It was not begun until the 1930s, and instead of developing in an empirical fashion, the zonal scheme that resulted owed much to the British scheme of Elles & Wood (1914). Upper Ordovician rocks lie outside the main goldfields, with the most graptolitic sequences outcropping either in isolated 'windows' surrounded by Cenozoic rocks (northwest of Melbourne), or in narrow, structurally complex belts (Mount Easton, Wellington River). Consequently, the zonal scheme was never seriously tested as a mapping tool.

Thomas & Keble (1933) subdivided the Upper Ordovician into three stages: (1) Gisbornian, based on sections along Jackson and Evans Creeks near Gisborne, about 35km northwest of Melbourne; (2) Eastonian, based on a small fauna from Mount Easton, 90km east of Melbourne; and (3) Bolindian, based on sections along Deep Creek and Konagaderra Creek near Bolinda, about 40km north of Melbourne. These were further subdivided into graptolite zones by Thomas (1935), with slight amendments by Harris & Thomas (1938c) and Thomas (1960b). The stage and zone boundaries were not accurately defined, and the Eastonian-Bolindian boundary especially has given much difficulty. Thomas & Keble (1933) listed Pleurograptus as a middle Bolindian form but Thomas (1935) used it as zonal form for his early Bolindian Zone of Pleurograptus sp. Harris & Thomas (1938c) suggested that the Zone of Pleurograptus might be better transferred to the Eastonian to give better similarity with the British succession, but Thomas (1960b) included it in the Bolindian without further comment. Most authors stressed that much more work was necessary before a definitive zonal scheme could be devised. To this end, Harris & Thomas (1955) began what was to be a series of papers describing the rich and well-preserved Wellington River faunas, but this work unfortunately ceased at the death of Dr. Harris in 1957. The writer (A.M.M.V.) has examined much of their large collection, in which virtually the whole of the Upper Ordovician is represented, and has also studied Eastonian and Bolindian faunas from the Bolinda-Darraweit Guim region, from the Mount Easton belt, and from the Deddick region in eastern Victoria (VandenBerg, 1979a, 1979c, 1980a). This has shown that the previous zonal scheme represents a useful framework, but needs revision, especially in the Eastonian and Bolindian.

Gisbornian. The subdivision of this Stage into a lower Zone of Nemagraptus gracilis and an upper Zone of Climacograptus peltifer and Diplograptus multidentis (Thomas, 1935, 1960b) follows Elles & Wood's (1914) subdivision of the Glenkiln Shale in Britain. The exact limits of the stage, especially the lower boundary, are not yet settled. Thomas (1960b) placed the base at the incoming of his 'Leptograptid fauna', implying that this coincides with the appearance of N. gracilis. Thomas & Keble (1933) however noted that Dicranograptus brevicaulis and Dicellograptus sextans occur in the upper beds of Loc. Ba 67 near Clarkefield (i.e. the type locality of Zone Da4), below the first appearance of N.

gracilis. This did not matter very much at first, since Thomas & Keble (1933) and Thomas (1935) included the modern Da4 Zone of G. teretiusculus in their Gisbornian. The difficulty appears to have been overlooked when Harris & Thomas (1938c) transferred the G. teretiusculus Zone to the new Darriwilian Stage, commenting that it differed from the Gisbornian only by the absence of the Dicranograptidae. Since the first appearance of dicranograptids has traditionally been regarded as the best place for the Darriwilian-Gisbornian stage boundary, this practice is followed here, but it leaves a small unzoned interval below the base of the N. gracilis Zone.

Climacograptus peltifer was used as the sole index fossil for the upper Gisbornian until Thomas (1960b) added Diplograptus multidentis. Riva (1976) considered C. peltifer to be conspecific with C. bicornis bicornis, which ranges through almost the whole of the Gisbornian. Most Victorian records of D. multidentis are probably misidentifications of Orthograptus calcaratus acutus and it is very doubtful that D. multidentis is present in Victoria.

The Gisbornian stage encompasses the ranges of Dicellograptus sextans and/or D. divaricatus, D. cf. intortus, Climacograptus bicornis bicornis, and Pseudoclimacograptus scharenbergi, all of which are common. Glossograptus hincksi also ranges to the top of the stage.

The early Gisbornian Zone of Nemagraptus gracilis is characterized by N. gracilis, N. sp. cf. exilis (which is more abundant), and Reteograptus geinitzianus, and contains one or two species of Didymograptus, last surviving representatives of the Dichograptidae. Corynoides curtus australis, 'Diplograptus' tardus, and Orthograptus calcaratus acutus first appear high in the zone. Dicranograptus brevicaulis is rare, but the longer-ranging D. nicholsoni and D. ramosus (sensu lato) are quite common.

Late Gisbornian faunas differ by the absence of Nemagraptus and Reteograptus geinitzianus and by the abundance of Corynoides curtus australis, Orthograptus calcaratus acutus, and O. calcaratus vulgatus. Climacograptus bicornis tridentatus is confined to this interval, and C. caudatus and Neurograptus margaritatus appear in the upper part of it.

Gisbornian rocks are known from the Heathcote Belt and most areas east of it. Early Gisbornian faunas (N. gracilis Zone) occur in tiny fault enclaves in the Heathcote Belt near Heathcote; in the Darraweit Guim Province between Gisborne, Romsey and Melbourne (Thomas & Keble, 1933); and in the Mount Easton Province at Phosphate Hill near Mansfield (VandenBerg, 1979b), at 8-Mile Creek in the Upper Howqua River, at Enoch's Point, and in Deep Creek near Walhalla. More complete sections occur in the Mount Wellington Belt at Wellington River, and in the Mallacoota Belt around Deddick. Faunas of broad (undifferentiated) Gisbornian age occur in the Tabberaberra Belt at Tabberaberra and at Nowa Nowa in the Mallacoota Belt.

Eastonian. The subdivision of the Stage into a lower Zone of Climacograptus baragwanathi and an upper Zone of Dicranograptus hians (Thomas, 1960b) was modelled on the British Zones of Climacograptus wilsoni and Dicranograptus clingani. For a time, C. baragwanathi was thought to be closely related to and perhaps even conspecific with C. wilsoni, whilst D. hians (sensu lato) was often misidentified as D. clingani (Elles & Wood, 1906; Thomas, 1935; Harris & Thomas, 1938c, 1954, 1955). In both cases, the similarities are quite superficial. Dicranograptus hians hians is of little value as zonal index species because its range completely overlaps that of C. baragwanathi.

Eastonian rocks are easily distinguished from older and younger strata by the absence of Climacograptus bicornis (diagnostic for Gisbornian) and C. hastatus (diagnostic for Bolindian), and by the presence of C. spiniferus and Orthograptus quadrimucronatus (sensu lato). The new subdivision of the Eastonian proposed here is applicable to the Wellington River section and to several measured sections in the Warbisco Shale near Deddick. Both have complete Eastonian sequences in which the two lower zones occupy very thin intervals, whereas the two upper zones are much thicker. This is probably a good indication of their relative time span, because both sections are composed of monotonous black shale. The four new zones are:

Ea1 Zone of Climacograptus spiniferus n. subsp.: The index fossil (figured as 'C. bicornis var. inequispinosus' [nom. nud.] in Thomas, 1960b) differs from C. spiniferus spiniferus by its extraordinarily long virgella (at least 30 mm long in mature specimens); the other basal spine is of normal length (2mm or less). A new subspecies of Orthograptus calcaratus with four very stout, strongly curved horizontal basal spines is also confined to this zone. Longer-ranging forms which make their first appearance include Dicranograptus hians hians, Dicellograptus cf. flexuosus, Diplograptus ingens, Climacograptus spiniferus spiniferus and Orthograptus quadrimucronatus (sensu lato). Corynoides curtus australis is still very abundant.

Ea2 Zone of Climacograptus baragwanathi: the index fossil with its peculiar basal appendage is not very common. Dicranograptus nicholsoni, D. ramosus (sensu lato), D. hians hians,

Diplograptus ingens, Climacograptus caudatus and Neurograptus margaritatus, and Corynoides curtus australis which occurs sparingly, all disappear at or near the top of the zone.

Ea3 Zone of Dicranograptus hians kirki: the index species, D. hians kirki Ruedemann (= D. tealei Harris & Thomas) is a descendant of D. hians hians with twisted and usually coiled stipes, and is very common. Longer-ranging forms making their first appearance include Leptograptus eastonensis, L. capillaris, and Climacograptus tubuliferus. Dicellograptus elegans occurs sparingly, and Climacograptus dorotheus is rare. Climacograptus tubuliferus nevadensis also occurs, but it is much more abundant in the succeeding zone. The zone has also yielded several fragments of a very large Pleurograptus, the earliest known representative of this genus in Victoria.

Ea4 Zone of Dicellograptus gravis: D. gravis Keble & Harris is here regarded as a senior synonym of D. alector Carter. It is a very robust species whose large thecae have strongly convex free ventral walls, and is common throughout the zone. 'Reteograptus' pulcherrimus, a descendant of O. quadrimucronatus which has lost most or all of its periderm, makes its first appearance.

Apart from their absence from the Heathcote Belt, the distribution of Eastonian rocks is similar to that of the Gisbornian. All four zones are present in the Warbisco Shale of the Deddick region and the Mount Easton Shale of Wellington River, and probably also in the same unit near Mount Easton and in the Tabberaberra Belt at Tabberaberra. The upper zones are known from the Riddell Grits of the Darraweit Guim Province and in boreholes at Phosphate Hill, near Mansfield.

Bolindian. The subdivision of this Stage into a lower Zone of Pleurograptus and an upper Zone of Dicellograptus cf. complanatus was adopted by Thomas (1935) and Harris & Thomas (1938c) from the British scheme of Elles & Wood (1914), albeit with considerable reservation. Both names are unsatisfactory, the first because Pleurograptus linearis simplex, on which the Zone of Pleurograptus was based, is too rare to be of much use, and the second because 'D. cf. complanatus' in fact refers to misidentified specimens of Dicellograptus ornatus and D. minor. The Zone of Climacograptus uncinatus and Zone of Dicellograptus ornatus and Climacograptus latus are proposed instead.

The only complete Eastonian to late Bolindian sequence known so far is in the Warbisco Shale at Mountain Creek. In this, the Bo1 Zone of Climacograptus uncinatus occurs about 2 m above the highest Eastonian fauna with Dicellograptus gravis and is characterized by abundant C. uncinatus, C. hastatus and C. longispinus longispinus and less common Dicellograptus cf. morrisi. At Wellington River, a similar assemblage is found together with Pleurograptus linearis simplex, Leptograptus eastonensis, L. capillaris and 'Reteograptus' pulcherrimus, and with rare specimens of the long-ranging 'Diplograptus' tardus, the probable ancestor of the late Bolindian Climacograptus latus.

In the Mountain Creek section, an 18 m thick unsampled interval separates the Bo1 faunas from typical late Bolindian faunas. Detailed sampling of this interval is necessary before a formal number is given to this late Bolindian Zone of Dicellograptus ornatus and Climacograptus latus. The fauna of this zone is characterised by abundant D. ornatus, C. latus, C. longispinus supernus, C. hastatus, and occasionally abundant Dicellograptus complexus and Paraorthograptus pacificus pacificus. Pleurograptus linearis cf. linearis occurs with this assemblage at Darraweit Guim. Orthoretiograptus denticulatus, a probably descendant of 'Reteograptus' pulcherrimus, is rather rare but is present in many localities.

In the Darraweit Guim Province, late Bolindian faunas are well represented in the Bolinda Shale, but C. uncinatus is only known from a single locality along a fault. Both zones are present in fault-disrupted sections at Mount Matlock and Wellington River, and in the Deddick region (Mountain Creek and McLaughlans Creek). Other records are from widely scattered localities near Walwa (late Bolindian) and Myrtleford in the Tabberaberra Belt, and Phosphate Hill near Mansfield (zone not known). This is more a reflection on the limited collecting than of the true distribution of the rocks.

B. Other biostratigraphic subdivisions in mainland Australia (B. D. Webby)

(i) North Australian conodont zones and stages

Druce & Jones (1971) established a Lower Ordovician conodont zonation, based on the succession in the Ninmaroo Formation of the Georgina Basin, western Queensland, with some six distinct assemblage zones, from the Cordylodus proavus Zone at the base to the Chosonodina herfurthi-Acodus Zone at the top. Introducing the stages, Jones et al. (1971) merely assigned the lower three zones to the Datsonian, and the upper three, to the Warendian. The Datsonian, its base defined by the first appearance of diagnostic conodonts of the Cordylodus proavus Zone, included the succeeding Zones of Oneotodus bicuspatatus-Drepanodus

simplex and Cordylodus oklahomensis-C. lindstromi. The Warendian, its base characterized by the incoming of elements of the Cordylodus prion-Scolopodus Zone, had the Zones of Cordylodus rotundatus-C. angulatus and Chosonodina herfurthi-Acodus also assigned to it. A stratigraphically higher, post-Warendian (possibly earliest Arenig) assemblage zone, the Drepanodus? gracilis-Scolopodus sexplicatus Zone was added by Jones (1971), based on the upper part of the Pander Greensand in the Bonaparte Gulf Basin.

Using the conodont assemblage zones, Jones (1971) was able to establish close correlations between the respective Lower Ordovician successions of the Georgina, Bonaparte Gulf and Daly River Basins in northern Australia. However, elsewhere in Australasia the scheme has limited usefulness for correlation purposes. Datsonian conodonts have been recorded from Dolo Hills, western New South Wales (Column 17, and explanatory notes), and representatives of the Drepanodus? gracilis-Scolopodus sexplicatus Zone recognized in the Summit Limestone of New Zealand (Column 60). Precise correlation between the respective Victorian graptolite and northern Australian conodont biostratigraphic schemes is restricted by the almost complete lack of direct tie lines. An upper limit of age may be provided by the occurrence of a Bendigonian graptolite in the Swift Formation. The Swift Formation is now thought to be a weathering product of the uppermost Ninmaroo Formation (Shergold & Druce, 1980). The representatives of the Chosonodina herfurthi-Acodus and D.? gracilis-S. sexplicatus Zones in the uppermost part of the Ninmaroo Formation (Datson Member), probably occupy levels stratigraphically below the horizon with the Bendigonian graptolite, and may therefore be tentatively assigned a late Lancefieldian age.

(ii) Australian trilobite zones and faunas

Unfortunately the Datsonian and Warendian trilobite faunas of Australia are virtually undescribed. In the Georgina Basin, Jones *et al.* (1971) and Shergold (1971) recorded a Datsonian fauna characterized by occurrences of leiostegiids, Kainella-like richardsonellinids and Onychopyge. Asaphellus makes its appearance in the Warendian, and it is associated with further leiostegiids, richardsonellinids and dikelocephalinids. Pliomerids also make their appearance in rocks of equivalent age in the Bonaparte Gulf Basin. Similar Datsonian and Warendian trilobite assemblages have been recorded by Shergold (1971) from the Gnalta Shelf of western New South Wales. The Digger Island Limestone of Waratah Bay, Victoria (Lindner, 1953), has a fauna of leiostegiids, Kainella-like richardsonellinids and pliomerids of possible Warendian age.

In central-western New South Wales, Webby (1974) has recognized four stratigraphically distinct Upper Ordovician trilobite faunules, named after their most common constituent species, the Pliomerina prima, the P. austrina, the Malongullia oepiki and the 'Illaenus' incertus faunules. The M. oepiki faunule is associated with graptolites of late Eastonian age (Moors, 1970). The faunal scheme has proved to be useful for local correlations in the central-west of New South Wales. Amphilichas encyrtos is one species which, in addition to occurring in the P. austrina assemblage in N.S.W., is also known along with a new species of Pliomerina in the Tasmanian assemblage OT15 (Banks & Burrett, 1980).

(iii) West Australian conodont, graptolite and trilobite biostratigraphy

McTavish & Legg (1976) introduced a series of informally numbered conodont and macrofaunal (graptolite and trilobite) zones for the Lower-Middle Ordovician succession of the Canning Basin. A generalized range chart of key conodont species also depicted the limits of the conodont 'zones' OCA to OCJ. Their distribution in the local formations of the basin was indicated in the text. Unfortunately, no attempt was made to define the 'zones' with reference to type successions, for example, in the Emanuel Formation where McTavish (1973) had already established a phylogeny of prioniodontacean conodonts as a basis for a zonation. The Emanuel Formation was reported by McTavish & Legg (1976) as having representatives of Zones OCA-OCD, but the precise stratigraphic limits of each zone were not indicated. Legg (1978) has since reported that Zone OCA and lower part of Zone OCB, including Paltodus inconstans, Scandodus furnishi, Acodus deltatus, Scolopodus rex and Paroistodus proteus, occur in the lower half of the Emanuel Formation (but not the lowermost beds). The upper part of Zone OCB and Zone OCC with occurrences of Paroistodus parallelus and Prioniodus elegans, and Zone OCD, characterized by Prioniodus evae communis and Protopanderodus rectus are recorded from the upper half of the Emanuel Formation. Stratigraphically higher zones are only recognized in the subsurface parts of the Canning Basin. Zone OCF is typified by the presence of Histeodella sinuosa, Zone OCH has the first appearance of Phragmodus, and Zones OCI and OCJ have occurrences of Eoplacognathus suecicus and E. foliaceus (McTavish & Legg, 1976; Legg, 1978).

Only a few elements of Canning Zones OCA and lower part of OCB (Scandodus furnishi, Scolopodus quadraplicatus and Ulrichodina) are also found as characteristic members of the Drepanodus? gracilis-Scolopodus sexplicatus Assemblage Zone of Jones (1971). Others, such

as Acodus deltatus and Paroistodus proteus, suggest a slightly younger age. Significantly, A. deltatus is found in an assemblage of the Summit Limestone in New Zealand (Cooper & Druce, 1975) stratigraphically higher than the occurrence of elements of the D.? gracilis-S. sexplicatus Zone.

In a modified and more detailed graptolite-trilobite scheme than that proposed originally in McTavish & Legg (1976), Legg (1978) recognized six, biostratigraphically distinct 'faunas'. Again, these have informal status as no type localities have been defined. Adelograptus and Clonograptus characterize the graptolite component of Fauna 2. Associated conodonts belong to the Zones OCA and lower part of OCB. A much more diverse graptolite fauna appears in Fauna 3. In the lower subdivision (subfauna 3a), Tetragraptus fruticosus (4br.), T. quadribrachiatum, Goniograptus thureau, Didymograptus latus, D. similis and D. extensus occur. The horizons containing this graptolite assemblage in the Emanuel Formation are situated in the upper half, at about the level of conodont Zone OCC (and below occurrences of Prioniodus evae communis). Legg (1978) has suggested that this graptolite subfauna (3a) correlates with the Bendigonian, probably with the lower half of the Victorian stage. A slightly younger subfauna (3d), from the Wilson Cliffs Sandstone, contains the first phyllograptids (Phyllograptus anna) and Didymograptus bifidus. In terms of the Victorian stages this suggests a correlation with the Chewtonian or early Castlemainian. Tasmanian faunal assemblage OT8 also contains phyllograptids including P. anna and, in about the same horizon, a conodont assemblage with Prioniodus evae (Banks & Burrett, 1980).

Legg (1978) recognized a gap in the faunal succession of the Canning Basin, between Faunas 3 and 4. Fauna 4 is recorded as having representatives of horizontal didymograptids, the first sinograptids (Holmograptus lentus) and diplograptids (Pseudoclimacograptus and Glyptograptus) and the last tetragraptids. With its occurrences of Pseudobryograptus incertus, Holmograptus lentus and a species of Glyptograptus allied to G. intersitus, it may be correlated with the Glyptograptus intersitus Zone of the Darriwilian (Da2) in Victoria. Fauna 5 is characterized by the appearance of Diplograptus ellesi, Amplexograptus confertus, Nicholsonograptus fasciculatus and Pseudoclimacograptus remus. Legg (1978) tentatively correlated Fauna 5 with the Victorian Diplograptus? decoratus Zone (Da3). Didymograptus artus, D. stabilis, Glyptograptus situlus and Hallograptus hirtus make their appearances in Fauna 6, and Amplexograptus confertus continues to be present. At this level, there are marked differences between the contemporaneous Canning Basin and Victorian faunas caused by provincial or tectono-environmental factors which prevent precise correlations being made. Tentatively, Fauna 6 may correlate with the Victorian Darriwilian Da3 or Da4.

In addition to the conodont, graptolite and trilobite biostratigraphic schemes, Combaz & Peniguel (1972) have outlined a palynological zonation for the subsurface part of the Canning Basin.

(iv) New South Wales coral and stromatoporoid faunas

A coral-stromatoporoid biostratigraphic subdivision was proposed by Webby (1969, 1972, 1975) for use in local correlation of the Upper Ordovician limestones of central-western New South Wales. The earliest assemblage is Fauna I, and it is typified by occurrences of abundant labechiid stromatoporoids, a varied element of tabulate corals including many species of Tetradium, and the rugose coral Hillophyllum priscum. It is most characteristically developed in the Fossil Hill Limestone Member of the Cliefden Caves Limestone. Fauna II is distinguished by the first appearance of clathrodictyid and cliefdenellid stromatoporoids, by abundant heliolitids and by the first appearance of Palaeophyllum. The base is defined by the 'E' horizon of Percival (1976), some 94m above the bottom of the massive Boonderoo Limestone Member of the Cliefden Caves Limestone in the Licking Hole Creek area, where the first clathrodictyids Ecclimadictyon nestori and Plexodictyon? appear (Webby & Morris, 1976). The Fauna II assemblage also occurs in the Large Flat Limestone Member of the Cliefden Caves Limestone, directly underlying the Malongulli Formation with its graptolite fauna suggestive of late Eastonian age (Moors, 1970).

Fauna III, which has previously been undivided, is now subdivided into IIIa and IIIb. Fauna IIIa is characterised by the first solitary streptelasmatids (McLean & Webby, 1976), the first halysitids (Webby & Semeniuk, 1971), the last appearance of Cliefdenella and the presence of Plexodictyon? cascum (Webby & Morris, 1976). It is represented in the Clearview Limestone Member of the Ballingoolle Limestone (Bowen Park Group), in the middle part of the Cargo Creek Limestone and in the unnamed limestone within the lower part of the Goonumbla Volcanics near Gunningbland. The succeeding Fauna IIIb exhibits a varied tabulate and rugose coral fauna including abundant favositids and halysitids, Plasmoporella inflata, and commonly, species of Favistina and Palaeophyllum. It is well developed in the upper parts of the Cargo Creek and Canomodine Limestones. Limestone breccias in the Malongulli

Formation (late Eastonian - early Bolindian) include representatives of both Faunas IIIa and IIIb. Fauna IV has a restricted distribution at the top of the Malachi's Hill Beds. Its rich rugose and tabulate coral assemblage includes Bowanophyllum pilatum, Rhabdelasma exigua, Palaeophyllum macrocaule, Favistina, Catenipora clausa, Adaverina acritos and abundant favositids (McLean & Webby, 1976; Webby, 1977). This may represent a late Bolindian fauna.

In terms of relationships between the 'coralline' elements of the Tasmanian assemblages (Banks & Burrett, 1980) and the New South Wales coral and stromatoporoid faunas, it seems likely that OT14 (Tetradium-Foerstephyllum) correlates with Fauna I, OT16 (Palaeophyllum) with Fauna II, and OT19 (favositid-halysitid) with Fauna IIIb. The coral assemblages of the Trelawney and Uralba Beds of north-eastern New South Wales (Philip, 1966; Hall, 1975) bear closest resemblances to Fauna IIIb.

C. Tasmanian fossil assemblages (M. R. Banks with contributions by C. F. Burrett, J. Laurie and B. Stait)

Details of these assemblages and reasons for the correlations used are provided in Banks & Burrett (1980). It should be noted that the name for Assemblage OT6 has been amended from Tritoechia sp. nov. in Banks & Burrett to T. florentinensis following description of that species by Laurie (1980).

(i) Algae

Algae are abundant on some horizons, often as oncolites, and present in many of the subtidal beds in the Gordon Sub-group. With Maclurites sp. in the Cashions Creek Limestone are three species of Girvanella (Banks & Johnson, 1957). In the Benjamin, Ida Bay, Bubs Hill, Queenstown, Smelters, Chudleigh and Railton Limestones and at Precipitous Bluff, Calathium sp. occurs in one or more horizons (it has been referred to as Receptaculites sp., e.g., Hill, 1955 and Banks, 1957; and Ischadites, e.g., Corbett & Banks, 1974). Within the Gordon Sub-group, Solenopora and its allies and several types of dasyclad algae are relatively common.

(ii) Stromatoporoids and corals

These groups are particularly useful for rough correlation in the field within Tasmania. Some of the stromatoporoids have been described by Webby (Webby & Banks, 1976; Webby, 1979) and the corals by Hill (1942; 1955). Stromatoporoids, Labechia aff. prima, Stratodictyon vetus and Stromatocerium bigsbyi enter in the Chazy prior to the first occurrence of corals (?) in the form of Lichenaria which is associated with Labechia banksi. A little higher Rosenella and ?Cryptophagmus first appear. Tetradium, Eofletcheria and Pachystylostroma enter a little higher followed by Foerstephyllum. Some heliolitids occur on about the same level as the first Tetradium. Somewhat higher Pachystylostroma is relatively common and associated with Labechia, Labechiella, and Rosenella. Just below the siltstone with Pliomerina, Palaeophyllum enters and heliolitids occur. Higher up Bajgolia occurs and then, near the top of the limestone, a large species of Aulacera, Clathrodiction molense, C. plicatum, Ecclimadiction undatum, Favistina, Plasmoporella, Favosites marginatus, and cateniporines such as Falsicatenipora (?) chillagoensis, occur.

The corals and stromatoporoids allow correlation with limestones in New South Wales.

(iii) Annelida

Vertical burrows, some demonstrably U-shaped, are abundant in quartz-rich sandstones at the top of the Denison Sub-group. They provide readily traceable mapping horizons and locally important members or formations (e.g. Pipestem Sandstone, Tubicolar Sandstone, Moina Sandstone). The burrows are ecologically significant but not biostratigraphically useful.

(iv) Bryozoa

Only two species of Bryozoa have been described from Tasmania, Stictopora zeehanensis Ross and Amplexopora queenstownensis Ross, but Bryozoa are abundant on many levels in the Gordon Sub-group. A Stictopora species is common with Pliomerina in the Lords Siltstone and its equivalents but is not restricted to that unit.

(v) Gastropoda

Gastropods are among the first fossils to appear in the succession as marine transgression occurred in the Lower Ordovician but preservation precludes precise identification. Within the Canadian Lecanospira tasmanensis Kobayashi occurs at several places. The Whiterockian Karmberg Limestone contains Teichiispira. Maclurites sp. (Banks & Johnson, 1957) is common in Chazy rocks in which it is associated with bellerophonitids

such as ?Tropidodiscus and ?Bucania. At higher levels Eunema, Raphistomina, Hormotoma, Helicotoma, Holopea and Lophospira have been noted or described (e.g. Etheridge, 1896) or figured (Johnston, 1888) but the fauna is very inadequately known.

(vi) Cephalopoda (B.S.)

Correlation of the Ordovician sequences in Tasmania based on cephalopods is difficult, due to the largely endemic fauna. Teichert (1947), and Teichert & Glenister (1953) describe the following endoceroids from Adamsfield - Manchuroceras steanei, M. excavatum, Suecoceras robustum, Piloceras tasmaniense, Utoceras?, and Allocotoceras insigne - this Manchuroceras-Piloceras association being typical of the Upper Canadian. Teichert & Glenister (1953) also described Nybyoceras multicubiculatum and N. paucicubiculatum from Railton and Ormoceras johnstoni from Zeehan. Flower (1957, p.7; 1968) assigned N. multicubiculatum and N. paucicubiculatum to Wutinoceras and O. johnstoni to Adamsoceras which are only found in the Whiterockian Stage. The Tasmanian fauna also contains a number of non-endemic genera which are only of slight value for correlation due to their long ranges - Armenoceras sp., Beliotoceras kirtoni, Discoceras idaense, Gorbyoceras sp., Mysterioceras australe, Anaspyroceras anzaas, Anaspyroceras sp., and Ephippiorthoceras decorum. The remaining Ordovician cephalopod fauna consists of as yet undescribed new genera and the following endemic species Hecatoceras longinquum, Tasmanoceras zeehanense, Stromatoceras eximium, and Gordonoceras bondi.

(vii) Pelecypoda

Johnston (1888) figured two pelecypods from the Gordon River in western Tasmania and Etheridge (1896) described Leptodomus? nuciformis from Zeehan. More recently Pojeta & Gilbert-Tomlinson (1977) have described a number of pelecypods from western Tasmania and they are known to be widespread. Their stratigraphic value is not, however, yet known.

(viii) Rostroconchia

Etheridge (1883) figured a rostroconch from the 'Arenig' Caroline Creek Sandstone and this was assigned to Tolmachovia by Pojeta & Gilbert-Tomlinson (1977), who recorded also a Bransonia from Zeehan.

(ix) Trilobites

Hystericurus is the oldest trilobite recognised in the Ordovician part of the Denison Sub-group and continues into the top of the Florentine Valley Formation. Dikelokephalina sp., Nyaya sp. and Parapilekia are the next entrants into the section followed by Ekeraspis, Asaphopsis and ?Pliomerina. At a higher level cf. Tasmanocephalus enters followed by Carolinites, Asaphellus and Tasmanocephalus. Pliomerina, cf. Ceraurinella and Amphilichas encyrtos occur in, and to some extent characterise the Lords Siltstone which also contains an Ampyx sp. and a trinucleid close to Guandacolithus. In the Upper Member of the Benjamin Limestone and Eokosovopeltis sp. occurs, and in the Westfield Sandstone a trinucleid close to Guandacolithus and a synhomalonotid close to Calymene birmanica are found. Illaenus sp., Bumastoides spp., cheirurid, encrinurid and harpid trilobites are also known. Dalmanitina sp. occurs in Upper Ordovician (or Lower Silurian) siltstones at Flowery Gully.

(x) Ostracoda

This group is common but has as yet been recorded only in the Karmberg Limestone and in the Lords Siltstone (Corbett & Banks, 1974). A new trilobate genus is common in Blackriveran-Rocklandian age strata.

(xi) Echinodermata

'Cystoid' plates and rare calices occur in the Florentine Valley Formation (Corbett & Banks, 1974) and crinoids occur in the Gordon Sub-group as separate plates. No echinoderms have been described from the Tasmanian Ordovician and the group is not known to have stratigraphic value.

(xii) Graptolites (C.F.B.)

Graptolites are rare in the Ordovician of Tasmania. The presence of Psigraptus in Assemblage 3 of the Florentine Valley Mudstone suggests correlation to Lancefieldian 1.5 or Cooper's (1979c) Medial Tremadoc Assemblage 3. Clonograptus rigidus is found above Psigraptus associated with Assemblage 4 in calcareous siltstones and suggests a Lancefieldian 2 or 3 age (Quilty, 1971). The highest fossil assemblage of the Florentine Valley Formation contains Didymograptus gracilis, D. cf. mundus and Tetragraptus sp. which suggest a Chewtonian or Castlemanian age (Corbett & Banks, 1974). Only one Ordovician graptolite (Loganograptus cf. logani) has been found in the Mathinna Beds of eastern Tasmania and this

suggests a Castlemanian age (Banks & Smith, 1968). Phyllograptus anna and P. ilicifolius are found near the base of the Karmberg Limestone. P. ilicifolius occurs in the Chewtonian and the two species occur together in the Garden City and Phi Kappa Formations of the Basin Ranges, within the Zones of T. fruticosus and D. protobifidus (Ross & Berry, 1963, pp. 81-83) and also with the D. nitidus and I. gibberulus Zones in the Lake District of England (Jackson, 1962). Graptolites have not been found above this level within the major sections of the Gordon Subgroup carbonates. Recently (in the 1979-1980 field seasons) graptolites (bispinose Climacograptus, Diplograptus, Orthograptus and Dicellograptus) were found at Surprise Bay, in a deep-water shale/micrite sequence. They suggest a 'Caradoc' age. However, further collecting of complete rhabdosomes is needed for precise age determination.

Graptolites have recently been found in the Westfield Sandstone. Trinucleids indicate that the lower beds of this formation are Ordovician. These beds are overlain by strata containing Glyptograptus persculptus Salter, Climacograptus normalis Lapworth (s.s.) and rare specimens of Atavagraptus and ?Akidograptus which suggest correlation to 'the persculptus zone or an horizon low in the acuminatus zone (more likely the latter)' (Baillie et al., 1978).

At Flowery Gully a siltstone contains ?Pleurograptus and ?Reteograptus and may be Upper Ordovician.

(xiii) Conodonts (C.F.B.)

Conodonts are common in the Karmberg Limestone and lithological correlates, indicating an age range from late Arenig to Llanvirn for that formation. A fauna from the base of the Karmberg being studied by Burrett and Stait contains species such as Prioniodus intermedius and Juanognathus variabilis that are identical to those from the top of the Prioniodus evae Zone in Argentina (see Serpagli, 1974). Collections from higher in the Karmberg have yielded species such as Histiodela sinuosa that are well known in the North American Whiterockian (faunas 3 and basal 4 of Sweet & Bergström, 1976). Conodont yields from higher parts of the Gordon Sub-group are usually very low and are possibly attributable to harsh peritidal environmental conditions and a very high rate of sedimentation. Phragmodus flexuosus (faunas 5-6 of Sweet & Bergström, 1976, Chazy) is found just below and just above the Cashions Creek Formation, throughout the basal oncolitic member of the Chudleigh Limestone at Mole Creek and in several other equivalent sections in the state. It is associated with Panderodus sp. nov. and Belodina alabamensis. Above this Chazyan fauna is a probably Blackriveran age fauna containing Phragmodus sp. nov., Tasmanognathus careyi and Chirognathus monodactylus (Burrett, 1979). Phragmodus undatus enters just below the Lords Siltstone (and its correlates), and probably marks the base of the Rocklandian (Sweet & Bergström's fauna 8). Multielement conodonts, superficially similar to certain species of Plectodina, Oulodus and Aphelognathus, occur in the Upper Member of the Benjamin Limestone and correlates. The highest conodont fauna is widespread and consists of B. compressa, P. undatus and Oulodus robustus, suggesting that the carbonate sequence is not younger than early Maysvillian. The recent discovery of a deep water 'Caradoc' fauna at Surprise Bay that includes Prioniodus spp., Amorphognathus spp., and Protopanderodus liripipus associated with a bispinose Climacograptus (see preceding discussion of graptolite occurrences) will eventually help in the intercontinental correlation of the higher parts of the Gordon Sub-group.

(xiv) Brachiopods (J.L.)

Brachiopods are probably the most temporally widespread group of fossils in the Ordovician and Silurian successions of Tasmania. Despite this, very little work has been published. Brown (1948) described three species from the Florentine Valley Formation and more recently Laurie (1980) has described orthides from the Florentine Valley Formation and Karmberg Limestone. Genera and species of Canadian age include: Apheoorthis humboldtensis Laurie, Nanorthis subcarinata Laurie, Tritoechia lewisi Brown, Syntrophopsis karmbergi Brown, Tritoechia florentinensis Laurie, ?Rhysostrophia, Tritoechia careyi Brown, Tritoechia karmbergensis Laurie, Archaeoorthis carinata Laurie and n.gen.aff. Taffia. Whiterockian genera include: Hesperonomiella spp., n.gen.aff. Calyptolepta, Aporthophyla and n.gen.aff. Parastrophinella. Chazyan genera include: Leptellina, ?Glyptomena, Apatomorpha, n.gen.aff. Ishimia spp., Oepikina spp., ?Strophomena, n.gen.aff. Teratelasma, Bellimurina, Dactylogonia, n.gen.aff. Parastrophinella, Anoptambonites, Hesperoorthis, Rhynchotrema, and ?Megamyonia. Blackriveran genera include: n.gen.aff. Lepidocyclus spp., n.gen.aff. Plectrothis spp., Strophomena, Rhynchotrema, Hesperoorthis, and Murinella. Trenton genera include: Dinorthis spp., Holtedahlinella, Strophomena spp., Hesperoorthis, Rhynchotrema spp., Protozyga, Hallina and Ptychopleurella. Cincinnati genera include: Dinorthis, Rhynchotrema, Strophomena, ?Hallina, and n.gen.aff. Catazyga. Llandovery genera include: Isorthis, ?Onniella, Hirnantia spp., Eostropheodonta, Plectothyrella and Kinnella kielanae Temple.

The Ordovician brachiopod faunas show strong affinities with those of the American realm (sensu Williams, 1973) and particularly with those of Kazakhstan and Southern China.

D. Correlation with standard British and North American subdivisions (B. D. Webby)

Correlation between the standard British Series (Arenig-Ashgill inclusive) and the Victorian Stages is based on graptolites, and follows that recommended by Strachan (in Williams et al., 1972). The only substantial differences are that the latest Darriwilian (Da4) is equated with the late Llanvirn (Skevington & Jackson, 1976), and a gap is shown between the Llanvirn and Llandeilo, because a part of the British succession, according to Jaanusson (1979), is not included in either Series. The Tremadoc is included as a British Ordovician Series, though most British workers favour its assignment to the Cambrian (Williams et al., 1972).

North American Stage and Series correlations mainly follow those given by Jaanusson (1979). The exceptions are at the base and top of the succession. A slight adjustment to the correlation of the lower limits of the Canadian Series is required because trilobites of its lowermost zone, the Missisquoia Zone, have been found by Fortey & Skevington (1980) in allochthonous blocks, stratigraphically below occurrences of the basal Tremadoc index fossil, Dictyonema flabelliforme (sensu lato). The Cambrian-Ordovician boundary in North America must therefore be placed above the base of the Missisquoia Zone, and this consequently means that the lowermost part of the Canadian has a latest Cambrian age. Mitchell & Bergström (1977) have noted that the top of the North American Upper Ordovician standard sequence in the Cincinnati region is incomplete. The best known section through the latest Ordovician-earliest Silurian is on Anticosti Island, and Twenhofel's (1928) Gamachian Stage is available for this post-Richmondian Ordovician part of the section. It would appear to be equivalent in age to the British Hirnantian Stage (Williams et al., 1972; Jaanusson, 1979).

3. SYSTEMIC BOUNDARIES

A. Cambrian-Ordovician boundary (B. D. Webby)

Aspects of defining the Cambrian-Ordovician boundary in Australia have previously been discussed by Thomas & Singleton (1956), Jones et al. (1971), Webby (1976; 1978), Druce (1978a), Cooper (1979c) and Cooper & Stewart (1979). As Druce (1978a) has noted, the boundary in Australia has been traditionally drawn at the base of the Tremadoc.

Shergold, Cooper, Druce & Webby (in press) have reviewed what they regard as the best known and most fossiliferous sections across the Cambrian-Ordovician boundary in Australia, New Zealand and Antarctica. They conclude that in the graptolite sequences only two sections, at Lancefield in Victoria (see Column 23) and Aorangi Mine in New Zealand (see Column 59), provide reasonable biostratigraphic control. 'A Cambrian-Ordovician boundary' they write 'placed within or at the top of the Tremadoc, rather than at the base as in current usage, can be positively identified and should enable a convenient classification of the sequence.' In the Lancefield section, this could be between La1.5 and La2 (base of Adelograptus victoriae and Dictyonema macgillivrayi - appearance of diverse graptolite assemblage), or between La2 and La3 (base of Tetragraptus approximatus).

The most complete biostratigraphic subdivision of platform sequences is that based on trilobites and conodonts from the carbonates in the Burke River Embayment of the Georgina Basin, western Queensland (see Column 11). Of the three stages, the late Cambrian Payntonian is based on trilobites (Shergold, 1975), and is divided into a lower Pseudagnostus quasibilobus-Tsinania nomas Assemblage Zone (with abundant tsinaniids), and an upper Mictosaukia perplexa Assemblage Zone (with abundant saukiids). The succeeding Datsonian and Warendian are defined using conodonts, each with three assemblage zones (Jones et al., 1971). The Cambrian-Ordovician boundary has been recognized by the incoming of conodonts of the Cordylodus proavus Assemblage Zone. The appearance of C. proavus also defines the base of the Datsonian. Along with the lack of continuity of diagnostic faunas across the boundary interval, Jones et al. (1971) and Shergold (1975) have used different faunal groups to define the zones of the latest Cambrian and earliest Ordovician, respectively. The unfortunate consequence of this has been the recent recognition of an overlapping relationship between the Payntonian and Datsonian Stages. Landing et al. (1978) have found C. proavus with trilobites in the late Cambrian Acado-Baltic Acerocare Zone, below the appearance of Dictyonema flabelliforme and its allies of early Tremadoc age in New Brunswick, Canada. This is equivalent to C. proavus extending down into the latest Cambrian Corbinia apopsis Subzone of the Saukia Zone in the North American province. Landing et al. (1978) have claimed an approximate correlation of the Acado-Baltic Cambrian-Ordovician boundary (base of the Tremadoc) with the Saukia-Missisquoia zonal boundary in the North

American province. Fortey & Skevington (1980) have placed the boundary even higher, on the basis of finding trilobites of the Missisquonia Zone in allochthonous blocks stratigraphically below Dictyonema flabelliforme sensu lato. This leads to the suggestion that, provided there is strict worldwide contemporaneity of the C. proavus fauna, then in northern Australia the base of the Tremadoc, and the position of Cambrian-Ordovician boundary, lies well within the Cordylodus proavus Assemblage Zone, with the base of the Datsonian, of latest Cambrian age. In all probability, as suggested by Druce (1978b), the late Payntonian Mictosaukia perplexa Zone overlaps the lower part of the early Datsonian C. proavus Zone. The Cambrian-Ordovician boundary may therefore be assigned a position at the top of the M. perplexa Zone or, judging from Fortey & Skevington's findings, even higher.

If a Cambrian-Ordovician boundary were to be adopted internationally at a higher level, either within, or at the top of the Tremadoc (Henningsmoen, 1973), it would be possible to establish precise correlation within the continuous succession of conodont assemblage zones in northern Australia (Jones et al., 1971; Druce & Jones, 1971). However, it would remain difficult to establish close, direct correlation between the independently established and geographically restricted graptolitic and conodont zonal schemes of the Victoria trough, and the northern Australian platform successions, respectively.

B. Ordovician-Silurian boundary (A. H. M. Vandenberg and B. D. Webby)

Expression of the Benambran Orogeny in eastern Australia is widespread, and the number of sections with a continuous record of sedimentation across the Ordovician/Silurian boundary is strictly limited. Especially rare are deposits of proven early Llandovery age, and late Bolindian to earliest Llandovery shelly faunas. For the present graptolites prove to be by far the most important group of organisms for use in establishing this boundary in Australia. Potentially the most important sections are located in the Deep Creek area of Victoria (Thomas & Keble, 1933; Vandenberg et al., 1976; Webby, 1976) and in the Florentine Valley area of Tasmania (Baillie et al., 1978; Baillie, 1979). No succession in New South Wales has yet been demonstrated to exhibit a complete record of beds across this interval.

The best known Victorian sequence is at Darraweit Guim, in the Deep Creek area (see Column 25). The thin (20 m) Darraweit Guim Siltstone, containing Dalmanitina (D.) darraweitensis, rare Climacograptus sp. and Glyptograptus sp. of the G. tamariscus group, may be either latest Ordovician or earliest Silurian. It overlies the Bolinda Shale with its rich D. ornatus-C. latus Zone fauna, and underlies the Deep Creek Siltstone which is probably entirely Llandovery in age. The lower part of the Deep Creek Siltstone contains rare diplograptids, including several new species, but no monograptids. The early Llandovery genus Akidograptus has been recorded from a section in which a substantial portion of the basal Deep Creek Siltstone is faulted out (Vandenberg et al., 1976).

In the Mount Easton Province, upper Llandovery rocks (Jordan River Group) are exposed in the Mount Easton Fault Belt but they are in fault contact with the Upper Ordovician Mount Easton Shale (Vandenberg, 1975). The same is also the case at Wellington River (Harris & Thomas, 1954). No rocks of Early Silurian age have been recorded from the Tabberaberra Belt, but the presence (previously unsuspected) of late Bolindian graptolites near Myrtleford and Walwa suggests that this largely unmapped region may also contain Llandovery sediments.

Recent mapping in the Deddick region (Mallacoota Belt) by Vandenberg and his colleagues has led to the discovery of a thick marine sequence of Early Silurian age in what was formerly regarded as an Upper Ordovician sequence. The Yalmy Group, largely of Llandovery age, overlies the Warbisco Shale with its rich early Gisbornian to late Bolindian graptolite faunas (see Column 31). The basal beds of the Yalmy Group still contain late Bolindian graptolites, but the exact position of the Ordovician-Silurian boundary is not clear: the next fossiliferous band is much higher in the Yalmy Group. It contains Climacograptus cf. miserabilis, Glyptograptus cf. lanpherei, Petalograptus cf. palmeus, Retiolites perlatus, Monograptus convolutus and Pristiograptus aff. regularis, indicative of a mid-Llandovery age (British Zone of M. convolutus).

In Tasmania, the Westfield Sandstone appears to span the boundary (see Column 18). According to Baillie et al. (1978) and Banks & Burrett (1980), the lower part includes brachiopods and pelecypods of North American Richmondian aspect, the graptolite Glossograptus, a trinucleid related to Guandacolithus and a synhomalonotid allied to Calymene birmanica. Higher in the sequence there is an horizon containing graptolites of the early Llandovery persculptus or acuminatus Zones (Baillie et al., 1978; Baillie, 1979).

4. ALPHABETICAL LIST OF ROCK UNITS

Notes on the Ordovician or presumed Ordovician stratigraphic units of each of the 62 columns of the correlation chart (Plate 1) are the responsibility of the following authors: B. D. Webby, columns 1-17 and 32-55; M. R. Banks, C. F. Burrett, J. Laurie, B. Stait,

columns 18-22; A. H. M. Vandenberg, columns 23-31; R. A. Henderson, columns 56-58; R. A. Cooper, columns 59-62.

A few, ill-defined stratigraphic units, which have either been introduced without definition or lack diagnostic Ordovician fossils, have been excluded from the correlation chart. These units, all from New South Wales, include the Hawkes Creek Beds (Brunker, 1968a), Hell Hole Beds (McIlveen, 1975), Hoskins Formation (Bowman, 1976), Jindalee Beds (Basden, 1974), Lue Beds (Offenberg *et al.*, 1971), Mugincoble Beds (Brunker, 1968b), St. Andrews Beds (Brunker, 1968a), and Tomingley Beds (Brunker, 1968a).

Notes on the informally named units of the Warburton Shelf of South Australia (Columns 13 and 14), the Dolo Hills area of western New South Wales (right side of Column 17), west central and eastern Victoria (Columns 23, 24, 26, 28, 29 and 30), the Wagga Metamorphic Belt of south central N.S.W. (Column 32) and north-eastern N.S.W. (Column 54), have been included at the end of this alphabetical listing of rock units.

Abercrombie Beds

(51)

Deformed sequence of quartz-rich greywackes and slates, some 7600 m thick (Hobbs, 1965; Hobbs & Hopwood, 1969). Considered to be the oldest rocks exposed in the Trunkay area (Stevens, 1975, p.56). Packham (1969, p.89) and Offenberg (1974, p.9) have recorded graptolites suggesting an Upper Ordovician age. Relationships with overlying beds obscured by large intrusive body, the Wyangala Granite; presumed to be succeeded by the Kenyu Formation. Also, probably at least in part laterally equivalent to the Angullong Tuff.

Acton Shale Member

(36)

See discussion of Pittman Formation.

Adaminaby Beds

(35)

The Adaminaby Beds were not first named by Adamson (1955) as suggested by Moye *et al.* (1969) and White *et al.* (1977). First published reference to the name appears in Fairbridge (1953). They comprise a sequence of quartz-rich greywackes, siltstones, shales and cherts cropping out in the Snowy Mountains from north of Adaminaby to well south of Berridale (Moye *et al.*, 1969; White *et al.*, 1977). Graptolite assemblages are of Eastonian and Bolindian age (Sherrard, 1954; 1962; Adamson, 1955). See also discussion of Nungar Beds. The Binjura Beds and Coolringdon Beds (Joplin, 1942) of the Cooma area may also be correlatives but not the overlying volcanic-limestone Bransby Beds of Joplin (1943), which is now regarded as having a late Silurian-?early Devonian age (Richardson, 1979). Joplin's stratigraphic units have not been adopted by Hopwood (1976) who instead used four unnamed units for mapping in the area.

Angry Hill Sandstone

(23)

The name is being introduced by Vandenberg & Wilkinson (in prep.). Graptolites of the La2 Zone of Adelogr. victoriae range through the lower part of this 600 m thick unit; the La3 Zone of Tetragr. approximatus occurs in the upper 220 m of the sequence. The type locality of Zone La2 is probably situated near the base. The Sandhurst Beds of Cooper & Stewart (1979) are equivalent.

Angullong Tuff

(47, 50)

Main rock types are tuffs, andesitic flows, conglomerates, breccias, siltstones and occasional limestones. Conformable relationships are exhibited with the underlying late Eastonian-early Bolindian Malongulli Formation (Stevens, 1952) in the Cliefden Caves area, but are less certain in the vicinity of Mandurama. The base of the succession in the Cliefden Caves area is above the Zone of Climacogr. uncinatus. It ranges through the middle-late Bolindian with a diverse assemblage of Dicellogr. anceps Zone aspect towards the top, including Climacogr. supernus, C. latus, C. normalis and Dicellogr. ornatus ornatus (Jenkins, 1978). The sequence in the Mandurama area is thicker, at least 2440 m (Smith, 1966), and may include strata of Eastonian as well as Bolindian age unless there is an undetected break with the underlying Darriwilian-Gisbornian 'Malongulli Formation' of Smith (1966).

Anthill Black Shale

(59)

See discussion of Aorangi Mine Formation.

Aorangi Mine Formation

(59)

Predominantly of quartz-rich sandstone, flysch sandstone and siltstone and black shale, the Aorangi Mine Formation (Cooper, 1979b) is richly fossiliferous and comprised of four members.

(a) Malone Member (lowest). Mainly quartz-rich sandstone and siltstone (460 m thick), the member contains no age-diagnostic fossils. It is thought to be lower to middle Lancefieldian because it conformably underlies Lancefieldian (La2) beds of the Anthill Black Shale (see below).

(b) Anthill Black Shale. Siliceous black shale, chert and minor sandstone represent a condensed sequence, 150 m thick spanning five New Zealand graptolite zones equivalent to ten Victorian zones. Rich graptolite assemblages represent the (Victorian) Zones, La2, La3, Bel-4 (undivided), Ch1-2 (undivided), Ca1 and Ca2.

(c) Battery Member. Blue-grey siltstone, quartz sandstone and black shale, 80-100 m thick, contains rich graptolite horizons with fossils of the (Victorian) Zone of Isograptus victoriae maximus (upper part) and lower part of the Zone of Oncograptus; age thus ranges from late Castlemainian to early Yapeenian.

(d) Jimmy Creek Quartzite (highest). Predominantly quartz sandstone, the member contains rare thin black shales which are richly fossiliferous and represent the Zones of Oncograptus and Cardiograptus (Yapeenian).

Arthur Marble

(61)

The Arthur Marble as mapped by Grindley (1971) and Johnston (1974), is now recognised as comprising two carbonate bodies, (Grindley, in press; Cooper, 1979a), informally designated as Arthur Marble 1 and Arthur Marble 2.

From the upper beds of Arthur Marble 1, at Mount Owen, Simes (in press) records conodonts of Pygodus anserinus Zone age, equivalent to the late Darriwilian to early Gisbornian. The basal beds pass conformably down into Owen Formation (q.v.). Thickness is likely to be in the range 500-1500 m at Mount Owen and Mount Arthur.

Arthur Marble 2 consists of dark carbonaceous limestone with abundant crinoid fragments and is conformably overlain by Hailes Quartzite at Hailes Knob. In the Flora Saddle area it is underlain by Wangapeka Formation with graptolites of Gisbornian (Keble & Benson, 1929; Skwarko, 1962) or Eastonian (Cooper, 1971) age. In Takaka Valley poorly preserved corals, including Plasmoporella, 'Proheliolites' (Cooper, 1965), and conodonts (Wright, 1968) suggest an 'uppermost' Ordovician age. Thickness is at least 300 m at Hailes Knob.

Back Creek (Slate)

(22)

The lutite association of the Mathinna Beds (Banks, 1962) contains Loganograptus cf. logani J. Hall near Back Creek (long. 147°3.1'E, lat. 41°2.6'S) indicating a probable Castlemainian age for part of the association (Banks & Smith, 1968).

Ballast Beds

(42)

Rock types include greywackes, siltstones, slates and cherts. Thickness unknown. Fauna of radiolarians, an ostracode (Baker et al., 1975) and possible species of Monograptus (Gilligan, 1975) is not particularly age diagnostic. Baker et al., (1975) have suggested a late Ordovician-early Silurian age for the unit, and unconformable relationships with the underlying Girilambone Beds (see also Suppel & Stevens, 1973) and the overlying late Silurian-early Devonian Cobar Group. The Mount Dijou Volcanics (Brunker, 1967; 1968d) which include basalt flows, are thought by Scheibner (in Pogson & Scheibner, 1976, p.11) to be interlayered with the Ballast Beds.

Ballingoole Limestone

(45)

Conformably overlying the Quondong Limestone and succeeded disconformably by the Malachi's Hill Beds, this formation (upper part of the Bowan Park Group) has been subdivided by Semeniuk (1970; 1972) into three members:

(a) Corner Limestone Member (lowest). A 120 m-thick, massive unit with few age-diagnostic fossils, mainly heliolitid corals and stromatoporoids towards the base.

(b) Clearview Limestone Member. Informally known as the 'Streptelasma' unit, this 152 m thick unit contains a varied coral and stromatoporoid fauna with representatives of a Fauna IIIa assemblage, characterized by non-ceriod rugosans and halysitids (Webby & Semeniuk, 1969; McLean & Webby, 1976).

(c) Downderry Limestone Member (highest). Only 7.5 m thick, this calcarenitic unit exhibits elements of the 'Illaenus' incertus faunule (Webby, 1974).

Barton Limestone

(48)

Massive limestone with heliolitid corals Coccoseris and Propora, possibly of Fauna I-II age (Webby, 1969). Stevens (1957a) has suggested a correlation of the Barton Limestone (Packham & Stevens, 1955) with the Bowan Park Group. However, Coccoseris is only typically represented in the Daylesford Limestone and the Quondong Limestone (Semeniuk, 1970; 1972).

Battery Member

(59)

See discussion of Aorangi Mine Formation.

Benjamin Limestone

(18)

The main part of the Gordon Sub-group in the Florentine Valley (long. 146°27.5'E, lat. 42°37.5'S) comprises the Benjamin Limestone which is 900-1200 m thick. This limestone overlies the Cashions Creek Limestone gradationally and is overlain conformably by the Westfield Sandstone. In the Florentine Valley three members are recognised, the Lower Limestone Member, the Lords Siltstone and the Upper Limestone Member. The base of the Benjamin Limestone contains conodonts indicative of a late Chazyan age and the top, corals and conodonts suggesting correlation with the P. linearis Zone and the late Edenian or early Maysvillian. Shelly fossils other than those mentioned are abundant on some horizons and include brachiopods, bryozoans, gastropods, pelecypods, cephalopods, and trilobites (see Corbett & Banks, 1974, for details).

The Lords Siltstone which is only about 50 m thick, contains bryozoans, brachiopods, trilobites, ostracodes and dendroids and is approximately coeval with the C. wilsoni Zone of the Caradoc (Banks & Burrett, 1980). This fossil assemblage which is dominated by Stictopora and Pliomerina, is widespread in Tasmania.

Billabong Creek Limestone

(44)

The coral/stromatoporoid fauna belongs to Fauna II (Webby, 1969; Webby & Morris, 1976) and the trilobites include representatives of the Pliomerina austrina faunule (Webby, 1974), together suggesting a possible lower Eastonian age. A substantial break separates the formation from the underlying Nelungaloo Volcanics, now assigned a minimum, Lower Ordovician, age (Sherwin, 1979b). It is overlain apparently conformably by the Goonumbla Volcanics (the directly overlying Parkesolithus horizon at New Durran probably belonging to the Malongullia oepiki faunule of upper Eastonian age).

Birkenburn Beds

(39)

Rock types are quartz-rich greywackes, siltstones, shales, occasional cherts and a massive quartzite. A distinctive graptolitic shale unit, named the Merigan Black Shale (Felton & Huleatt, 1977) occurs in the upper part of the Birkenburn Beds. It is up to 150 m thick, and contains a graptolite fauna identified by Sherwin (in Felton & Huleatt, 1977) as including Orthogr. truncatus, O. quadrimucronatus, Climacogr. tubuliferus, Dicellogr. cf. forchammari flexuosus and Leptogr. cf. flaccidus, probably of late Eastonian to early Bolindian age.

Blathery Creek Volcanics

(48)

Name introduced informally by Wolf et al. (1968) for sequence of some 910 m of andesitic lavas, agglomerates and tuffs in the vicinity of Bakers Swamp. Interbedded limestone pod contains Girvanella. Conformably underlain by graptolitic Hensleigh Siltstone of middle Bendigonian age (Wolf et al., 1968; Packham, 1969, p.77; Webby, 1976). See also discussion of Fairbridge Volcanic Group.

Blue Hills Sandstone

(12)

Formerly at least in part the upper unit of the Mount Chandler Sandstone (Coats, 1963; Wopfner, 1969). This succession of quartz-rich sandstones, clayey sandstones and conglomerate bands is now referred to the Blue Hills Sandstone (Krieg, 1973). It exhibits only rare bedding-surface trails and Skolithos. It has been correlated, on lithological grounds alone, with the Stairway Sandstone of the Amadeus Basin (Krieg, 1969). See also discussion of 'Munda sequence'.

Bogolo Formation

(41)

Sequence of slates, phyllites, arenites and minor cherts, conformable with the overlying Wagonga Formation (Wilson, 1969; Chalker & Bembrick, 1975; 1977). Lack of palaeontological control prevents firm age assessment but, from its stratigraphic position directly beneath the Wagonga Formation, it seems likely to be of ?Early or Middle Ordovician age.

Bogong Creek Beds

(33)

Belt of quartz-rich greywackes, siltstones, shales and subordinate cherts containing an Eastonian graptolitic fauna (Sherrard, 1954). The 'Toolong Beds' of Svenson (1957, unpubl.; Menzies, 1965) is probably a northerly extension of the Bogong Creek Beds.

Bolinda Shale

(25)

Name being introduced by VandenBerg (in prep.). Much of the interval which should contain faunas of the Climacogr. uncinatus Zone is covered by Tertiary basalt. D. E. Thomas (unpubl. MS) recorded C. uncinatus and Pararetiograptus? pulcherrimus from Deep Creek near Surprise Gully. Thomas & Keble (1933) listed several localities from Deep Creek near Sunbury, from which they recorded Pleurograptus, but judging from other forms they listed, these localities may belong to the Zone of D. ornatus and C. latus. Rocks of the late Bolindian Zone of D. ornatus and C. latus outcrop extensively near Darraweit Guim and Bolinda, and these contain Dicellogr. ornatus ornatus, D. ornatus minor, Orthogr. amplexicaulis, Climacogr. longispinus supernus, C. latus, C. tubuliferus, C. hastatus and Paraorthogr. pacificus. In the basal beds of the zone, this assemblage is accompanied by Pleurogr. linearis cf. linearis, Climacogr. longispinus longispinus, and Pseudoplegmatochr. n.sp.

Boltons Beds

(34)

Age and stratigraphic relationships of the unfossiliferous Boltons Beds remain in some doubt. Menzies (1965), Moye et al. (1969) and Owen & Wyborn (1979) have considered the quartz-rich sandstone sequence to pass upwards into the Gisbornian chert-volcanogenic sequence of the Kiandra Group without apparent break. The formation is therefore taken to have a Darriwilian age. Others, however, have argued that the Boltons Beds are younger than the Kiandra Group (Crook et al., 1973; White et al., 1977). Owen & Wyborn's (1979) recent studies seem to demonstrate conclusively that this is not so. There is an unnamed sequence of 'metabasalts' at Jagungal which underlies the Boltons Beds and may have caused confusion, but intrusive equivalents to the volcanic rocks of the Kiandra Group have been found intruding the Boltons Beds.

Boonderoo Limestone Member

(47)

See discussion of Cliefden Caves Limestone.

Bowan Park Group

(46)

See discussion of the three constituent formations, the Daylesford Limestone (lower), the Quondong Limestone (middle) and Ballingoolle Formation (upper).

Bryo Gully Shale

(23)

The type locality of the La1.5 Zone of Psigraptus and Clonograptus (Cooper & Stewart, 1979) is situated some 60 m above the base. Graptolites belonging to the La2 Zone of A.

victoriae first appear in the uppermost 12 m of the formation (VandenBerg & Wilkinson, in prep.)

Bubalahla Formation

(54)

A sequence of cherts, black shales and quartz-rich greywackes in excess of 500 m thick, with graptolites at various horizons ranging from Eastonian to early Bolindian (Scheibner, 1973).

Bubs Hill Limestone

(20)

In the upper part of the valley of the Nelson River and on Bubs Hill (long. $145^{\circ}46.3'E$, lat. $42^{\circ}07'S$) are isolated outcrops of limestone. At Bubs Hill the limestone is almost horizontal, faulted down between the Precambrian rocks and overlain conformably by a quartzite, a correlate of the Crotty Quartzite. The limestone is fossiliferous in several horizons and the corals Eofletcheria ida, Nyctopora sp. and Plasmoporella sp. have been described (Hill, 1942; 1955).

Bullongong Shale Member

(38)

See discussion of Foxlow Beds.

Burra Burra Creek Formation

(53)

Directly underlain by Bubalahla Formation. In part overlain and in part intertonguing with Rockley Volcanics. Sequence of unfossiliferous quartz-rich greywackes and slates (Bembrick et al., 1971; Scheibner, 1973).

Bynguano Quartzite

(16)

A succession of quartzites with interbedded siltstones and abundant Skolithos and Rusophycus (Cooper, 1975). In the lower part, the same leiostegiid and richardsonellinid fauna is found as at the top of the underlying Nootumbulla Sandstone (Shergold, 1971). In the upper part, asaphids, dikelokephalinids and protopliomerinids are represented, and are taken by Shergold and by Jones et al. (1971) to typify the Warendian.

Cabbage Tree Formation

(22)

In the Beaconsfield area (long. $146^{\circ}49.7'E$, lat. $41^{\circ}13.3'S$) a formation of conglomerate and quartz sandstone with minor siltstone and limestone beds is faulted into Cambrian or older rocks. The formation contains brachiopods, trilobites and conodonts which indicate correlation on the one hand with Faunal Assemblages 4-7, probably with 5, of the Florentine Valley Formation and conodont Zones D and E of the American Midcontinent (Gee & Legge, 1974; Kennedy in Banks & Burrett, 1980).

Camp Ridge Quartzite

(62)

Quartz sandstone and quartz conglomerate inferred to be of largely fluviatile origin (Laird et al., 1974) unconformably overlies late Idamean or post-Idamean Spurs Formation (Laird et al., in press; Cooper et al., in press). Marine shales near the base of the unit contain trace fossils Skolithos, Daedalus and Arthropycus (Cooper et al., 1976). Thickness is at least 3000 m (Laird et al., 1974) and possibly as much as 7000 m. Although fossils diagnostic of Ordovician age are unknown, the presence of Arthropycus near the base of the unit, together with its very great thickness, suggests that the upper beds may be of Early Ordovician age. The Riley Formation at Riley Ridge, Bowers Mountains (Laird et al., in press) is thought to be a lateral equivalent of the Camp Ridge Quartzite and thus may be also, in part, Ordovician.

Canomodine Limestone

(46)

The sparse, rather recrystallised and distorted faunal elements of the Canomodine Limestone (Stevens, 1950; 1957a) may be equated with better preserved counterparts in the adjacent, stratigraphically equivalent Cargo Creek Limestone. They include corals and stromatoporoids belonging to faunas II and III of Webby (1969; 1975). From tentative correlations these faunas span much of the Eastonian and the early Bolindian (see Webby &

Morris, 1976).

Cape River Beds

(58)

Graptolite faunas reported by Dear (1974) and McClung (1976) are of Lancefieldian and late Bendigonian ages respectively. They apparently come from the upper part of a substantial sequence which probably embraces much of the Lower Ordovician. Unit A of the Mount Windsor Volcanics underlies the Cape River Beds; unit B intertongues with them.

Cargo Andesite

(45, 46)

The rock types are mainly andesites, with some basalts, breccias and conglomerates. The formation underlies the Daylesford Limestone (Bowen Park Group) and equivalents, and is thus likely to be Darriwilian or older in age. No associated fossils have been found. Stevens (1957a) and Packham (1969) have correlated it with the Walli Andesite; Packham however has noted its more varied lithology. Ryall (1965) referred to a thickness in excess of 460 m.

Cargo Creek Limestone

(46)

Ecclimadictyon amzassensis and Tetradium cribriforme which occur in a thinly bedded unit (Quondong Formation equivalent) towards the exposed base of the Cargo Creek Limestone, represent Fauna II (Webby, 1969; Webby & Morris, 1976). Components of Fauna IIIa (Helicelasma, Quepora calamus and Cliefdenella etheridgei) are found in the middle part of the formation (McLean & Webby, 1976) and representatives of Fauna IIIb (abundant Favistina and favositids) occur in the upper part of the succession.

Carlo Sandstone

(9, 10)

In conformity with the underlying Nora Formation and the overlying Mithaka Formation, the predominantly quartz sandstone succession of the Carlo Sandstone contains a sparse undescribed shelly fauna, and abundant trace fossils of the Cruziana, Rusophycus, Arthropycus, Diplocraterion and Skolithos type (Draper, 1977). Its fauna has been viewed by Opik and Gilbert-Tomlinson (in Smith, 1972) as having a 'Middle Ordovician' aspect. Conodonts in the underlying Nora Formation suggest to Druce (in Draper, 1977) a late, but not latest, Arenig age. Shergold et al. (1976, fig. 15) have assigned the Carlo Sandstone to a latest Arenig to Llanvirn age. In a palaeoenvironmental reconstruction Draper (1977) has inferred that the Mithaka and Nora Formations are lateral equivalents of the Carlo Sandstone.

Carmichael Sandstone

(8)

Rock types include cross bedded sandstones with some thin interbedded siltstones and claystones. It represents the uppermost formation of the Larapinta Group, conformably overlying the Stokes Siltstone (Cook, in Wells et al., 1970). Trace fossils such as Cruziana occur. No age-diagnostic faunal elements are known.

Caroline Creek Sandstone

(21)

Below the limestones of the Gordon Sub-group in the Railton area (long. 146°23.9'E, lat. 41°17.3'S) are richly fossiliferous red or yellow sandstones which have long been known as Caroline Creek Sandstone. They contain brachiopods, gastropods, rare worm burrows perpendicular to the bedding and numerous trilobites one of which, Carolinites, first described from this unit, is widely spread in Early Ordovician rocks. The unit occupies the stratigraphic position of the Moina Sandstone (Banks, 1962, p.167).

Carranya Beds

(1)

Sequence of sandstones and siltstones with minor conglomerates, approximately 150 m thick (McTavish, in Playford et al., 1975). The fauna includes Dikelocephalina and Ophileta, suggesting a late Tremadoc age (McTavish & Legg, 1976).

Carriers Well Limestone

(57)

The Everetts Creek Volcanics is closely associated with the Carriers Well Limestone.

Both lie wholly within a fault zone and are a stratigraphic isolate (Arnold & Fawckner, 1980); shearing has disrupted their internal sequence. Corals suggest a late Ordovician or early Silurian age for some of the limestone (Hill, in White, 1965; Hill et al., 1969; J. S. Jell, pers. comm. to R.A.H.). An unpublished conodont fauna from some of the coralline limestone, however, suggests a Late Ordovician age (Telford, 1972).

Cartu Beds

(12)

These unfossiliferous sandstones, siltstones and shales (Krieg, 1973) comprise the topmost unit of the 'Munda sequence'. Upper boundary of unit unknown. Krieg et al. (1976, p.249) has regarded the unit as 'very tentatively' having a Middle or Upper Ordovician age.

Cashions Creek Limestone

(18)

An association of Maclurites and Girvanella in a richly oncolitic limestone characterises the Cashions Creek Limestone, a unit about 150 m thick which lies gradationally above the Karmberg Limestone and passes gradationally up into the Benjamin Limestone. The type area is in the Florentine Valley (long. 146°28.25'E, lat. 42°35'S) but the rock type is widespread and everywhere is of Chazyan age as shown by the species of Maclurites and the conodonts (Corbett & Banks, 1974).

Chatsworth Limestone

(11)

Shergold (1975) has recognized the Mictosaukia perplexa Zone (late Payntonian) in the upper part of the Chatsworth Limestone (Casey, 1959) of several sections. However, in the Dribbling Bore section, the topmost beds of the formation contain the succeeding Cordylodus proavus Zone (early Datsonian). Shergold assigned the perplexa Zone to the latest Cambrian. Druce (1978b), in contrast, has shown the perplexa Zone to have an overlapping relationship with respect to the proavus (Early Datsonian) Zone, and therefore likely to have an earliest Ordovician age. With the proavus Zone faunas now having been recognized in the North American latest Cambrian (see discussion of Systemic boundaries, Part 3), it seems more likely that most of the topmost beds of the Chatsworth Limestone belong to the Late Cambrian.

Cheesemans Creek Formation

(48)

Rock types include andesites, tuffs, greywackes and siltstones. Sherwin (1971; 1979a) has recognized four stratigraphically distinct graptolite horizons in the Cheesemans Creek Formation, the lower being assigned tentatively to the Eastonian and the succeeding three, to the Bolindian. Precise correlation is complicated by the fact that Orthogr. cf. apiculatus in the lowest horizon, and Amplexogr. cf. inuiti in the highest horizon have not been recorded from the Eastonian-Bolindian successions of Victoria (Webby, 1976), possibly as a consequence of the provincial differences which exist between the New South Wales and Victoria faunas.

Chocolate Sandstone

(20)

The part of the Upper Member of the Owen Conglomerate beneath the Haulage Unconformity (long. 145°35.6'E, lat. 42°04'S) was referred to as Chocolate Sandstone by Wade & Solomon (1958, p.383). The name was derived from an original division by Hills (1914) of the Owen Conglomerate; Étage 4 of Hills being 'white to deep chocolate brown' and more directly from Edwards (1943) and Conolly (1947).

Clark Sandstone

(4)

Glaucconitic and quartz sandstones in a succession up to 219 m thick. Öpik (in Kaulback & Veevers, 1969) and Jones et al. (1971) placed the Cambrian/Ordovician boundary at the junction between the Clark Sandstone and the overlying Pander Greensand, between the Payntonian (Öpik's faunal assemblages X and XI) and the Datsonian (early Tremadoc). On the other hand, Shergold (1971, p.398) has claimed an abundance of Richardsonellinae and Leiostegiidae considered to typify the Datsonian, in the uppermost beds of the Clark Sandstone. Druce (1978a) has referred to this horizon as marking the oncoming of glauconite into the predominantly quartz sandstone sequence.

Clearview Limestone Member

(45)

See discussion of Ballingool Limestone.

Cliefden Caves Limestone

(47)

A number of distinctive, mappable subdivisions of the Cliefden Caves Limestone (Stevens, 1952) were introduced informally by Webby (1969). Osborne (1978) gave the three members formal status, naming them, in ascending order, the Fossil Hill Limestone Member, the Boonderoo Limestone Member and the Large Flat Limestone Member. In the Licking Hole Creek area, Percival (1976) estimated a total thickness of some 363 m for the Cliefden Caves Limestone. The Fossil Hill Limestone Member and, for convenience, the lower, poorly fossiliferous 94 m of the succeeding Boonderoo Limestone Member (below the 'E' horizon of Percival, 1976) are assigned a coral and stromatoporoid Fauna I age (Webby & Morris, 1976). The remainder of the Boonderoo Limestone Member and the Large Flat Limestone Member are of Fauna II age.

Coolibah Formation

(10)

Interbedded limestones, dolomites, marls and chert lenses up to a maximum of 110 m thick. Both disconformable and conformable relationships have been recorded with the underlying Kelly Creek Formation. The formation has been represented as the lowest unit of the Toko Group (Casey, in Smith, 1965), but has recently been excluded from it on the grounds that it is unlike the succeeding 'siliciclastic' units (Draper, 1980b). It is succeeded conformably by the Nora Formation. Shergold *et al.* (1976) have referred to the age as 'Early Arenig' based on the conodont fauna. Similarly Gilbert-Tomlinson (1973) has alluded to an 'Arenig' age (see also Pojeta & Gilbert-Tomlinson, 1977). Wade (1977), in contrast, has referred to the nautiloids as suggesting a 'Whiterock' to slightly younger age (i.e. an equivalent Llanvirn age).

Corner Limestone Member

(45)

See discussion of Ballingool Limestone.

Corrie Member

(11)

See discussion of Ninmaroo Formation.

Cotton Beds

(44)

Sherwin (1970) recognized four stratigraphically distinct graptolite assemblages in the Cotton Beds. The lowest (fauna A) contained Climacogr. supernus and was viewed as a Bolindian assemblage; the next (fauna B), characterized by C. normalis, was interpreted as near the Ordovician/Silurian boundary. The succeeding faunas (faunas C and D) were dominated by monograptid species of late Llandovery (Early Silurian) age. Sherwin (1973) has argued for continuity of the Cotton Beds, but part of the formation is unexposed in an interval between the lower and upper units (i.e. between faunas B and C) and there are no records of early Llandovery zonal indices.

Cypress Hill Volcanics

(49)

Rock types include andesite, spilite, volcanic-derived sandstone and siltstone (Vandyke & Byrnes, 1976). Oldest rocks exposed in the core of the Oakdale Anticline. They are some 250 m thick and unfossiliferous. They correlate with the earlier, Walli-Cargo phase of andesitic volcanicity.

Daly River Group

(5)

Three formations of Middle Cambrian-Early Ordovician age are included in the Daly River Group (Randal, 1962; 1963), in ascending order, the Tindall Limestone, the Jinduckin Formation and the Oolloo Limestone (see discussion of latter two units).

Darraweit Guim Siltstone

(25)

This relatively thin (29 m thick) unit (VandenBerg, in prep.) contains abundant

disarticulated of Dalmanitina (D.) darraweitensis (Campbell, 1973) and rare graptolites, mainly Glyptograptus sp. of the G. tamariscus group. The precise age of the unit is not certain - it may be latest Ordovician or earliest Silurian.

Datson Member

(11)

See discussion of Ninmaroo Formation.

Daylesford Limestone

(45)

This 250 m-thick formation (lower part of the Bowan Park Group) comprises six members named, in ascending order, the Ranch Member (marl, mudstone and lithic sandstone), the Bourimbla Limestone Member, the Manooka Limestone Member, the Gerybong Limestone Member, the Glenrae Limestone Member and the Davys Plains Limestone Member (Semeniuk, 1972). The Bourimbla Limestone Member is characterized by occurrences of Eodinobolus, Alleynodictyon and Tetradium, the Manooka Limestone Member, by Ischadites and the Gerybong Limestone Member by an abundance of gastropods. Of Webby's (1969) coral-stromatoporoid associations, the Ranch, Bourimbla, Manooka and Gerybong Limestone Members contain elements of Fauna I, and the Davys Plains Limestone Member has characteristic representatives of Fauna II.

Denison Sub-group

(18, 19)

In its type area on the Denison Range (long. $146^{\circ}13'E$, lat. $42^{\circ}33'S$) the Sub-group comprises the Singing Creek Formation (Franconian), Great Dome Sandstone (?Late Cambrian), Reeds Conglomerate (age uncertain) and Squirrel Creek Formation (Early Ordovician). It is 3390 m thick and represents a Late Cambrian regression from marine proximal flysch through shallow marine, deltaic and fluvial sandstones to non-marine fanglomerate followed by an Early Ordovician transgression. The Tim Shea Sandstone is the lithostratigraphic equivalent of the Reeds Conglomerate (Corbett & Banks, 1974). The Florentine Valley Formation is at least in part correlative with the Squirrel Creek Formation. See discussion of Tim Shea Sandstone and Florentine Valley Formation.

On the flats north of Cave Hill, Ida Bay (long. $140^{\circ}51'E$, lat. $42^{\circ}26'S$) and continuing through to the Hog Back near Hastings Caves (long. $146^{\circ}50.8'E$, lat. $42^{\circ}24'S$) outcrop friable sandstones and quartzites which contain gastropods and trilobite fragments. The gastropods are similar to those in the Florentine Valley Formation.

Siliceous conglomerates and quartz sandstone outcrop on Point Cecil east of Prion Beach (long. $146^{\circ}36.4'E$, lat. $43^{\circ}33.6'S$) and are faulted against Ordovician limestone. They closely resemble units of the Denison Sub-group in other parts of Tasmania.

Despatch Limestone

(20)

The name Despatch Limestone was applied to limestone found in the Despatch Mine just north of Zeehan (long. $145^{\circ}20'E$, lat. $41^{\circ}52.8'S$). It occurs in a fault block lying between probable Cambrian rocks to the west and the Silurian Crotty Quartzite on King Extended Hill. Within the King Extended Hill block the limestone is overlain unconformably by the quartzite. Etheridge (1896) described molluscs and trilobites from the limestone including one species 'Amphion? brevispinus' very close to the Pliomerina species in the Lords Siltstone.

Digger Island Limestone

(28)

The shelly fauna of the upper part includes brachiopods, cystid plates, hyolithids, tentaculitids, rare nautiloids, and trilobites, including species of Geragnostus, Leiostridium, Protopliomerops, a kainellid, a pliomerid, and a true harpid. The assemblage belongs to the Kainella-Leiostridium Zone (Singleton, 1967), which is indirectly correlated with the La1.5 Zone of Psigraptus (see Barnes et al., 1976, and Cooper & Stewart, 1979).

Djagamara Formation

(7)

Glauconite in the sandstone and siltstone succession gives a probable minimum K/Ar value of 447 m.y. (Cooper et al., 1971), suggesting it represents a Middle Ordovician or earlier age. Wells (1972) has noted the lithological similarity of the Djagamara Formation to both the Pacoota Sandstone and the Stairway Sandstone of the Amadeus Basin, though in Wells et al. (1972) and Wells (1976) only a correlation between the Djagamara Formation and the Pacoota Sandstone is shown. Age-diagnostic fossils are lacking.

Downderry Limestone Member

(45)

See discussion of Ballingool Limestone.

Emanuel Formation

(1)

The formation contains representatives of graptolite/trilobite faunal assemblages 2, 3a and 3b of Legg (1978), and conodont 'zones' OCA-OCD of McTavish (in McTavish & Legg, 1976). Graptolites in faunal assemblage 3a are of Bendigonian age. Diverse nautiloid faunas also occur (Teichert & Glenister, 1954).

Ethabuka Sandstone

(10)

Only the lower part of the Ethabuka Sandstone (Draper, 1980b), some 36 m thick, is exposed in surface outcrop, and contains an undescribed Ordovician fauna of trilobites, brachiopods and molluscs, and the trace fossils Cruziana and Rusophycus. In the subsurface it is recorded by Shergold & Druce (1980, p.164) as attaining a thickness of 428 m, and by Draper (1980b) as some 1147 m thick. It is overlain unconformably by both Devonian Craven Peak Beds and where these beds are missing, by Mesozoic sandstones. It has recently been included as the uppermost constituent formation of the Toko Group (Draper, 1980b).

Everetts Creek Volcanics

(57)

See discussion of Carriers Well Limestone.

Fairbridge Volcanic Group

(48)

The Fairbridge Volcanics of Adrian (1971) are herein accorded group status. See discussion of the three constituent formations - in ascending order, the Mitchell Breccia, the Hensleigh Siltstone and the Blathery Creek Volcanics.

'Fenestella' Shale

(20)

A unit of black shales in the Linda Valley (long. $145^{\circ}35.9'E$, lat. $42^{\circ}0.39'S$) was given this name by Gregory (1905). These may be shales within the limestones of the Gordon Sub-group or weathered silty limestone (Hills, 1927, p.135) or a siltstone unit such as that which outcrops immediately below Crotty Sandstone on the southern slopes of Mt. Lyell (long. $145^{\circ}37.1'E$, lat. $42^{\circ}04'S$). Although this siltstone is buff coloured, it contains abundant fenestrate bryozoans (possibly Phylloporina) and occupies the stratigraphic position of the Westfield Sandstone. Its age is uncertain but it is presumably Early Silurian or Ordovician.

Florentine Valley Formation

(18)

At the top of the Denison Sub-group in the Florentine Valley area (long. $146^{\circ}29.2'E$, lat. $42^{\circ}42.9'S$) is the Florentine Valley Formation, a unit 390 m thick of calcareous siltstone, impure limestone and sandstone, which overlies the Tim Shea Sandstone gradationally and underlies gradationally the basal formation (Karmberg Limestone) of the Gordon Sub-group. In its type area the formation can be divided into three members, the Churchill Sandstone, the Pontoon Hill Siltstone and the Mt. Field Siltstone. The formation is marine and richly fossiliferous. Seven successive fossil assemblages have been recognised. These are from the base to the top as follows: 1. 'Lesueurilla' Assemblage, 2. Hystericurus-Apheoorthis Assemblage, 3. Dikelokephalina Assemblage, 4. Megistaspis-Clonograptus Assemblage, 5. Tritoechia lewisi Assemblage, 6. Tritoechia florentinensis Assemblage, and 7. Tritoechia careyi Assemblage. Assemblage 3 contains Psigraptus and is correlated with Lancefieldian 1.5, and Assemblage 2 contains fossils of Early Ordovician aspect. The age of Assemblage 1 is not yet determinable but is probably very Early Ordovician. The graptolites in Assemblage 7 suggest correlation with the nitidus or gibberulus Subzones of the D. extensus Zone (Banks & Burrett, 1980; Stait & Laurie, 1980).

Correlating, at least in part with the Florentine Valley Formation, is the Squirrel Creek Formation (Corbett, 1975), a sequence of about 600 m of fossiliferous marine sandstone, siltstone and impure limestone. It occurs at the top of the Denison Sub-group above the Reeds Conglomerate, and below the Gordon Sub-group in the Rasselas Valley at Squirrel Creek (long. $146^{\circ}18'E$, lat. $42^{\circ}30.2'S$). It contains brachiopods, gastropods (cf. Raphistoma sp.)

and trilobites (including Asaphapsis juneensis), and is Early Ordovician.

Flowery Gully Limestone

(22)

A thickness of 460 m of micritic limestone lies above ferruginous sandstone at Flowery Gully (long. 146°48.9'E, lat. 41°16'S) and is overlain, probably with paraconformity by a thin quartzite and a thick sequence of argillites or siltstone. The limestone contains very rare nautiloids and relatively abundant conodonts suggesting correlation with North American Midcontinent conodont faunas 1 to 4 (inclusive). The overlying siltstones contain rare brachiopods and trilobites (Dalmanitina sp.) and graptolites (?Pleurograptus and ?Reteograptus) suggesting a Late Ordovician age.

Fork Lagoons Beds

(56)

The Fork Lagoons Beds are a stratigraphic isolate of undetermined internal sequence and their fauna is undescribed. Conodonts listed for them suggest they correlate with the Amorphognathus ordovicicus Zone of the Baltoscandian region and Ordovician Zones 10 and 11 of North America (see Sweet & Bergström, 1971). Their conodont and coralline fauna was compared by Anderson & Palmieri (1977) and Palmieri (1978) to those documented by Philip (1966), Packham (1969), Webby (1969) and Hall (1975) from N.S.W. and that listed by Corbett & Banks (1974) for Tasmania.

Formation A

(59)

The youngest unit in the Aorangi Mine sequence is comprised of mainly siltstone and fine sandstone and is referred to, informally, as Formation A (Cooper, 1979b). Thickness is of the order of 1000 m (minimum thickness is 600 m). Dicellograptus is present in the lower part, Nemagr. gracilis is present in the upper part. The unit thus represents the lower Gisbornian. The trilobites Incaia bishopi and 'Ogygites' collingwoodensis are associated with the N. gracilis assemblage.

Fossil Hill Limestone Member

(47)

See discussion of Cliefden Caves Limestone.

Foxlow Beds

(38)

Oldershaw (1965) recognized and mapped a distinctive graptolitic black shale unit, named the Bullongong Shale Member, within the upper part of the Foxlow Beds. Graptolites from this member suggest a Late Ordovician - probably late Gisbornian to early Eastonian - age. Glasson & Paine's (1965) Beverley Beds and Railway Slates are correlatives of the Foxlow Beds and Bullongong Shale Member, respectively. To overcome Richardson's (1979) objection to the formal designation of a member from within a named unit of beds (rather than a formation) it may be best to follow the example of Felton & Huleatt (1977) - see discussion of Birkenburn Beds - and give the Bullongong Shale Member the status of a formation.

Gap Creek Formation

(1)

The Gap Creek Formation is sparsely fossiliferous, especially when compared with the underlying Emanuel Formation. A conodont fauna of Zone OCE age has been recorded by McTavish & Legg (1976). The brachiopod Spanodonta hoskingiae is reported by McTavish & Legg (1976) and Playford et al. (1975) to be the most common macrofossil, and it is considered by Legg (1978) to appear in his Subfauna 3b. Legg (1978) has correlated the Gap Creek Formation with the middle part of the subsurface Willara Formation.

Girilambone Group

(42, 43)

This unfossiliferous basement sequence, also referred to as the Girilambone Beds (Brunker, 1969), is probably of Cambrian or Early Ordovician age. It apparently unconformably underlies the Late Ordovician-Early Silurian Ballast Beds (Suppel & Stevens, 1973, p.174).

Golden Gully Beds

(50)

Succession of unfossiliferous, thin-bedded siltstones and shales with minor sandstones

and porphyritic intermediate igneous rocks, at least 1200 m thick, and overlain apparently conformably by the Sunny Ridge Beds (Smith, 1969; Webby, 1976).

Goldwyer Formation

(2, 3)

This richly fossiliferous, predominantly shale-limestone succession contains representatives of conodont 'zones' OCF-OCJ of McTavish (in McTavish & Legg, 1976; amended by Legg, 1978), microfloral (chitinozoan and acritarch) 'zones' 04 and 05 (Combaz & Peniguel, 1972) and graptolite/trilobite 'faunas' 4, 5 and 6 of Legg (1978). It has a widespread distribution in the Canning Basin. A few key graptolites have occurrences which suggest that the Goldwyer Formation correlates at least in part with the type Darriwilian in Victoria - for instance, Pseudobryogr. incertus and a species of Glyptograptus close to G. intersitus occurs in both Fauna 4 and Da2, while Amplexogr. confertus is found in Faunas 5 and 6, and in Da3.

Goondra Volcanics

(34)

Formerly mapped as Nine Mile Volcanics (Owen et al., 1974), the Goondra Volcanics are recognized by Owen & Wyborn (1979) as a thick sequence of low potassium basaltic to andesitic lavas and breccias, probably no older than Darriwilian, and equivalent to the lower part of the Temperance Formation. O'Hares Beds (Stapledon, 1957) and Cooper Mine Creek Volcanics (Moye, 1953) may be equivalents.

Goonumbla Volcanics

(44)

Apparently conformably overlying the Billabong Creek Limestone is a succession of shales and volcanics - the shales containing Parkesolithus gradyi, Orthogr. apiculatus and Dicellogr. elegans (Sherwin, 1973). The succeeding limestones yield elements of coral/stromatoporoid fauna IIIa (Webby & Morris, 1976) and, near the top, representatives of the 'Illaenus' incertus faunule (Webby, 1974). A varied brachiopod fauna also occurs (Percival, 1978; 1979a; 1979b). These limestones and shales should perhaps be regarded as part of separate, designated sedimentary units. The main volcanic mass seems to succeed these horizons. In the vicinity of Parkes and Forbes, Bowman (1974; 1976) has subdivided the Goonumbla Volcanics of Brunner (1972) into two flows (Nash Hill and Parkes Andesites) and two 'dominantly intrusive' units (Goonumbla and Bushman Andesites). Sherwin (1979b) has shown the Goonumbla Volcanics as having an intertonguing relationship with the overlying Cotton Beds.

Gordon Sub-group

(18, 19, 21)

A highly calcareous, usually limestone, sequence overlies the clastic sequence of the Denison Sub-group in many parts of Tasmania and is known as the Gordon Sub-group. The Gordon Sub-group is best exposed in the Florentine Valley area where it rests gradationally on the Florentine Valley Formation at the top of the Denison Sub-group and passes conformably into the Silurian Tiger Range Group. In its type area it consists of the Karmberg Limestone (at the base), the Cashions Creek Limestone, the Benjamin Limestone and the Westfield Sandstone (= Arndell Sandstone of Baillie, 1979) and is about 2350 m thick. It ranges in age from late Canadian at the base to Llandovery at the top (Corbett & Banks, 1974; 1975).

Sections through the Gordon Sub-group occur in isolated outcrops in southern Tasmania (Column 19) but have not been studied in detail because of difficulty of access. The most complete and most studied section is at Ida Bay (see discussion of Ida Bay Limestone). Oncolitic limestone with Maclurites occurs on the shore of New River Lagoon (long. 146°35'E, lat. 43°28.7'S), and at Judds Cavern (long. 146°36.7'E, lat. 43°15.4'S) and is correlated with the Cashions Creek Limestone. On the south-western slopes of Precipitous Bluff (long. 146°35.5'E, lat. 43°28.9'S) 130 m of calcarenite and micrite probably equivalent to the Lower Member of the Benjamin Limestone are overlain by 4 m of siltstone with Pliomerina, lithologically and faunally like the Lords Siltstone and then by a sequence of 230 m of siltstone with minor micrite. This is equivalent to the Upper Member of the Benjamin Limestone. On the western shoreline of Point Cecil (long. 146°36.1'E, lat. 43°33.3'S) is an outcrop of siltstone containing brachiopods, a raphiophorid and a trinucleid trilobite and conodonts. The raphiophorid species also occurs in the Lords Siltstone and the conodonts include Phragmodus undatus indicating a Trentonian or Cincinnati age. Surprise Bay (long. 146°39.4'E, lat. 43°35.2'S) is aptly named. Twelvetrees (1915) noted the presence of limestone there, expected to be similar to other outcrops of Gordon Sub-group. However, recent reconnaissance work has shown that there is a sequence about 250 m thick of micrite

with swarms of Telephina sp., Ampyxoides sp., Lonchodomas sp., Nileus and Pseudobasilicus interbedded with graptolitic (Climacograptus) shales. Biocalcarene lenses interbedded in the sequence probably are turbidity current deposits, laid down in deep water and contain trinucleids, ceratrinids and a proetid. North Atlantic province conodonts, though rare, occur in most micrite beds but are abundant in the calcarenites and suggest a Caradoc age. Near the top of the sequence the micrites contain a benthonic shelly fauna.

At Railton a thin fossiliferous siltstone separates the limestone of the Gordon Sub-group from the Caroline Creek Sandstone (Column 21). The Railton Limestone includes limestone at Blenkhorns Quarry, Railton (long. 146°25.4'E, lat. 41°19.9'S), with cephalopods, and overlying siltstone with brachiopods and the fossiliferous limestone in the Goliath Quarry at Railton (long. 146°24.9'E, lat. 41°20.2'S) which contains Maclurites, Calathium, bellerophonitids, cephalopods and conodonts. They range from Whiterockian at the base to Chazyan. The name Chudleigh Limestone first used by (Johnston, 1888) can be usefully applied to the limestones and associated siltstones in the Chudleigh and Mole Creek (long. 146°25'E, lat. 41°33'S) areas. The Chudleigh Limestone is about 1600 m thick and ranges in age from Chazyan at the base to Maysvillian at the top. At the base at Standard Hill is an oncolitic limestone above which are limestones, predominantly micritic, interrupted by a bryozoan and trilobite-rich siltstone faunally like the Lords Siltstone and overlain by a micrite with brachiopods and trilobites similar to those in the Westfield Sandstone.

Hanson River Beds

(6)

The succession has faunas of two different ages - one with a 'middle' Arenig, and the other with a 'late' Arenig or Llanvirn aspect (Druce, in Kennewell & Offe, 1979). Gilbert-Tomlinson (1976) recorded the Hanson River fauna, presumably the late Arenig or Llanvirn one, as being the same as that found in the upper part of the Stairway Sandstone.

Hensleigh Siltstone

(48)

Included among the graptolites are Tetragraptus fruticosus 3 br. and 4 br., and species of Dichograptus and Didymograptus, suggesting a mid-Bendigonian age (Packham, 1969, p.77). See also discussion of Fairbridge Volcanic Group.

Horn Valley Siltstone

(8)

Though the Horn Valley Siltstone is the most richly fossiliferous unit in the Amadeus Basin succession, its fauna remains one of the least well characterized. The diverse fauna includes the trilobites Carolinites, Lonchodomas and Prosopiscus, the graptolite Didymograptus, and abundant conodonts, considered by Druce and Jones (pers. comm. in Ritchie & Tomlinson, 1977), and by Cooper (1981) to be of mid-Arenig age. Overall, the Horn Valley conodonts are seen by Cooper to be more advanced phylogenetically (i.e. younger) than those in the Emanuel Formation of the Canning Basin (McTavish, 1973). Conodonts from the Horn Valley Siltstone in the vicinity of King Canyon, south-west of the George Gill Range have a late Arenig-Llanvirn aspect (G. M. Philip, pers. comm.) which may imply that deposition of the formation persisted longer, at least into the late Arenig, in some areas of the basin. Striking faunal similarities between the Horn Valley Siltstone and that of the Tabita Formation of Mt. Arrowsmith, western New South Wales (Warris, 1969; Shergold, 1971) suggest that they are at least in part stratigraphically equivalent.

Hotham Beds

(30)

Very little work has been done on the basement sediments of the Tabberaberra Belt. The eastern part of the belt consists of high-grade metamorphics and intrusives (biotite schist, migmatitic gneiss, gneissic intrusives) known as the Omeo Metamorphic Complex. In the less metamorphosed part of the belt, the oldest rocks comprise a thick sandstone-rich sequence for which Beavis (1962) introduced the informal name Hotham Slates. A Bendigonian graptolite (T. fruticosus 4-br.) was recorded from this unit in the upper Howqua River, at the extreme western margin of the belt (Harris & Thomas, 1938b), but the remainder was traditionally assigned to the Middle and Upper Ordovician. Recent discovery of another early Bendigonian fauna (Tetragr. cf. acclinans and T. fruticosus 4-br.) from Eskdale, at the eastern margin of the Omeo Metamorphic Complex (Kilpatrick & Fleming, 1980) now suggests that the largely unfossiliferous Hotham Beds are predominantly Early Ordovician. The uppermost beds, still dominated by sandstone, contain Darriwilian graptolites in several places: Da2 or Da3 at Thoona near Benalla (Pseudobryogr. incertus, Holomogr. cf. lentus, Glossogr. acanthus, Glyptogr. sp.), Da4 at Tabberaberra (Didymogr. sp., Isogr. ovatus, Glossogr. hincksi,

Syndyogr. sp., listed in Talent, 1963), and unspecified Darriwilian (Da3?) at Gibbo River (Phyllograptus nobilis, 'Diplograptus', Climacograptus, recorded by Harris & Keble, 1932).

Howqua Shale

(27, 29)

The type section of the Howqua Shale (Thomas & Singleton, 1956) along the Howqua River (Column 29) contains an La2 assemblage comprised of Adelogr. victoriae, Kiaerogr. antiquus, K. cf. pritchardi, Clonograptus, and Tetragr. decipiens (Harris & Thomas, 1938b).

Tiny fault slivers of cherty and somewhat phosphatic shale at Phosphate Hill near Mansfield are probably referable to the Howqua Shale (Column 27). One sliver contains an La3 assemblage comprising Tetragr. approximatus, T. decipiens, inarticulate brachiopods, and phyllocarid crustacea (Hall & Chapman, in Howitt, 1923).

Ida Bay Limestone

(19)

At Ida Bay (long. 146°57'E, lat. 43°28'S) an apparently gently folded sequence of fossiliferous micrite at least 350 m thick is exposed. This has been called the Ida Bay Limestone and can be correlated on palaeontological grounds with the upper part of the Cashions Creek Limestone and the Lower Member and perhaps part of the Upper Member of the Benjamin Limestone in the Florentine Valley. The base of the limestone is unknown and it is overlain unconformably by Late Palaeozoic tillite.

Indulkana Shale

(12)

Formerly regarded as the middle unit of the Mount Chandler Sandstone (Coats, 1963; Wopfner, 1969), this red and green siltstone and shale succession is now given independent formation status (Krieg, 1973). The reported, associated limestones (Coats, 1963; Krieg, 1969; 1973) are probably superficial caliche deposits. The fauna is restricted to evidence of activity of animals, including Skolithos and Diplocraterion. The Indulkana Shale has been correlated on lithological grounds with the Horn Valley Siltstone (Krieg, 1969).

Jerrawa Beds

(37)

Sherrard (1943) recorded a large number of species of Late Ordovician graptolites from different horizons in the succession (Browne, 1954; Cramsie et al., 1978). Packham (1969) has inferred them to range through Sherrard's (1962) Zones of Climacogr. peltifer, Orthogr. calcaratus & Plegmatogr. nebula, and Orthogr. quadrimucronatus & Pleurogr. linearis, from late Gisbornian to late Eastonian, possibly to early Bolindian (see also Offenbergl, 1974). Crook et al. (1973, fig. 6) mapped a separate chert unit within the Jerrawa Beds, suggesting that it might be an 'analogue' of the Acton Shale Member in the Canberra area. Sherrard (1939) originally referred to the Jerrawa Beds as a part of her Mundoonen Series. The Picaree Formation (Best et al., 1964) is probably at least in part equivalent to the Jerrawa Beds.

Jiggamore Member

(11)

See discussion of Ninmaroo Formation.

Jimmy Creek Quartzite

(59)

See discussion of Aorangi Mine Formation.

Jinduckin Formation

(5)

This formation which contains halite pseudomorphs, is considered to conformably overlies the early Middle Cambrian Tindall Limestone (Randal, 1962; Pontifex & Mendum, 1972), and to extend up into the Early Ordovician without unconformity. Towards the top, Jones (1971) has recognized the presence of two conodont zones, the late Warendian Chosonodina herfurthi-Acodus Assemblage Zone, and the 'basal Arenig' Drepanodus? gracilis-Scolopodus sexplicatus Assemblage Zone. The Manbulloo Limestone Member (Randal, 1962) is assigned a Cambrian age (Brown, in Sweet et al., 1974, p.85).

Junee Group

(18)

As at present used the Junee Group consists of the Denison Sub-group and the Gordon

Sub-group (Corbett & Banks, 1975).

Kangerong Sandstone

(26)

This formation (Kangerong Stage of Keble, 1950), although unfossiliferous, lies between fossiliferous beds with La2 and La3 graptolite faunas.

Karmberg Limestone

(18)

A formation of impure limestone and cherty limestone about 450 m thick overlies the Florentine Valley Formation conformably and underlies the Cashions Creek Limestone, also conformably in the Florentine Valley area (long. 146°28.5'E, lat. 42°40.8'S). At the base is a richly fossiliferous impure limestone with brachiopods, ostracodes, trilobites, cystoids, graptolites and conodonts. The fossils indicate an age high in the Arenig, approximately gibberulus Subzone of the D. extensus Zone. Within the formation Wutinoceras sp. and conodonts occur and suggest a Whiterockian age and the unit is overlain by limestone correlated with the Chazyan (Corbett & Banks, 1974; Banks & Burrett, 1980).

Kelly Creek Formation

(9, 10)

Except in the extreme easterly and westerly areas of outcrop, the Kelly Creek Formation has apparent conformable relationships, with the Ninmaroo Formation below and the Coolibah Formation above. However, in the west, in the Tarlton Range area, the formation rests with apparent conformity on the Tomahawk Beds, and it is succeeded directly by the Nora Formation (the 'Coolibah' facies seemingly being absent). In the most easterly outcrop, it rests disconformably on the Late Cambrian Georgina Limestone (Smith, 1972). Jones et al. (1971) reported an hiatus in the Kelly Creek Formation of the Toko and Tarlton Ranges because of a break in the succession of conodont faunas. The break is depicted by Shergold et al. (1976) as spanning an interval from middle to late Warendian, and by Shergold & Druce (1980) as extending from late Warendian to earliest Arenig, although no physical discontinuity has been demonstrated. While the Kelly Creek faunas remain undescribed, the nature and timing of the supposed break is in doubt. Possibly it represents no more than a short-lived early Arenig phase of regression (Webby, 1978). A dolostone unit within the formation has been named by Druce (in Radke & Duff, 1980), the Withillindarmna Dolostone Member.

Kenyu Formation

(51)

This succession of siltstones, slates and tuffs with some associated andesites and limestones (Packham, 1969), may be a correlative of the Angullong Tuff. However, no fossils have been found to help in determining its precise age. Offenbergl (1974) has noted that its base is faulted against Ordovician slates and quartz sandstones, possibly equivalents of the Abercrombie Beds. With respect to the overlying Silurian, both unconformable (Felton, 1974) and apparently conformable (Offenbergl, 1974) relationships are exhibited.

Kerridy Sandstone

(7)

This unfossiliferous sandstone sequence of possible fluviatile origin (Wells et al., 1972) has been correlated tentatively with the Ordovician Carmichael Sandstone or Stairway Sandstone of the Amadeus Basin (Wells, 1972). However it may be much younger, possibly Siluro-Early Devonian in age.

Lano Gully Sandstone

(23)

For convenience, the base of this unfossiliferous unit (VandenBerg & Wilkinson, in prep.) is usually taken as the base of the Tremadoc (Thomas & Singleton, 1956).

Larapinta Group

(8)

See discussion of Pacoota Sandstone, Horn Valley Siltstone, Stairway Sandstone, Stokes Siltstone and Carmichael Sandstone.

Large Flat Limestone Member

(47)

See discussion of Cliefden Caves Limestone.

Lords Siltstone

(18)

The middle member of the Benjamin Limestone in the Florentine Valley. See discussion of Benjamin Limestone.

Malachi's Hill Beds

(45)

Semeniuk (1970) mapped a number of subdivisions of the Malachi's Hill Beds, and first noted the faulted contact at the top. He also recognized the presence of a disconformity at the base (Semeniuk, 1972). Graptolites have been recorded from horizons in the lower part, and have suggested to Semeniuk (1970) an age near the Eastonian/Bolindian boundary or within the early Bolindian. Sherwin (1971, p.208) referred this part of the sequence to the early Bolindian. One of the key graptolites mentioned by Stevens (1957a) and Packham (1969, p.82) is Amplexogr. inuiti. The limestone and limestone breccia unit at the top of the formation contains a rich tabulate and rugose coral fauna, including Catenipora, Adaverina, favositids, Favositina-like forms, Grewingkia, Palaeophyllum, Bowanophyllum and Rhabdelasma, elements typical of Fauna IV (Webby, 1972; 1977; McLean & Webby, 1976).

Mallacoota Beds

(31)

This informal name is retained for the little-known and apparently unfossiliferous sequence of highly deformed phyllite, slate, micaceous siltstone, sandstone and minor quartzite of the eastern part of the belt. A single fossil locality, from a chert band at Cape Everard, has yielded the largest conodont fauna from the Victorian Ordovician. It includes the form taxa Periodon cf. aculeatus, P? cf. flabellum, Prioniodina macrodentata, Cordylodus cf. spinatus, Oistodus cf. lanceolatus, and Falodus cf. prodentatus (I. Stewart, pers. comm.), suggesting a late Darriwilian or early Gisbornian age. In the absence of reliable fossil data, a broad Early to Late Ordovician age is suggested for the Mallacoota Beds, and it is quite possible that the unit includes Silurian beds.

Equivalents of the Mallacoota Beds on the New South Wales side of the border are the extensive area of outcrop of Late Ordovician sediments named the Byadbo Beds (Menzies, 1965) east of the Snowy River. It includes rich graptolite assemblages at Stockyard Creek (Sherrard, 1962). A smaller area is the outcrop of metamorphosed sediments (the Ingeegoodbee Beds of Menzies, 1965), immediately west of the Snowy River.

Malone Member

(60)

See discussion of Aorangi Mine Formation.

Malongulli Formation

(47)

As originally defined by Stevens (1952), the succession originally comprised the calcareous siltstones, spiculites and limestone breccias of the Cliefden Caves area. The conception of the formation was, however, widened by Stevens (1957a) to include the siltstone-arenite facies of the Junction Reefs area, to the east of Cliefden Caves. The siltstone-arenite facies, more recently described by Smith (1966), is now recognized as constituting a distinctly older, Darriwilian-Gisbornian unit (see discussion of 'Malongulli Formation' of Smith). In the type area, and at Licking Hole Creek, the graptolite faunas suggest that the Malongulli Formation ranges from late Eastonian to early Bolindian (Moors, 1970; Percival, 1976; Jenkins, 1978). Climacogr. uncinatus is recorded by Percival and Jenkins from the uppermost beds of the formation. The Malongullia oepiki faunule (the Trilobite Hill fauna) occurs in the lower parts of the formation (Webby, 1974). Inarticulate brachiopods in the fauna have been described by Percival (1978). Limestone breccias in the lower and upper parts of the formation contain elements of coral/stromatoporoid fauna III (Webby, 1969; 1975; Webby & Morris, 1976). The Malongulli Formation also occurs in the Regan's Creek area, overlying the Regan's Creek Limestone (McLean, 1974).

'Malongulli Formation' of Smith

(50)

Stevens (1957a) and Smith (1966) regarded this unit as a different 'siltstone-arenite' facies of the Malongulli Formation. It contains graptolites of undoubted Darriwilian and Gisbornian age (Smith, 1966; Packham, 1969, p.80) - a lower fauna with Cryptogr. tricornis, Pseudotrigonogr. ensiformis, Loganogr. logani, Amplexograptus, Isograptus and Tetragraptus of probable Da3 age, and a higher assemblage with Glyptogr. teretiusculus, Dicellograptus and

Orthograptus of early Gisorbian age - and the trilobite Shumardia (Webby, 1973). Since Moors' (1970) revision of the graptolites in the type Malongulli Formation, it has been recognized as a distinctively older unit, for convenience called the 'Malongulli Formation' of Smith (Webby, 1973; 1974; 1976).

Manbulloo Limestone Member

(5)

See discussion of Jinduckin Formation.

Merigan Black Shale

(40)

See discussion of Birkenburn Beds.

'Middle Owen'

(20)

See discussion of Owen Conglomerate.

Millambri Formation

(46)

Ryall (1965) revised the Millambri Formation of Stevens (1957a) to exclude the lower part of it. As emended, Ryall recorded a lower member of massive, poorly bedded arenites and an upper member of predominantly banded siltstones. Locally developed volcanic-derived conglomerate and limestone lenses occur at the top of the formation (Ryall, 1965). The limestone in the vicinity of Liscombe Pools is reported by Percival (1976) to be separated by disconformity from the underlying Millambri Formation. Percival collected a middle Llandovery graptolite assemblage from just beneath the disconformity, and noted that the mainly Early Silurian Millambri Formation is in fault contact with the underlying Angullong Tuff. However, in the type area, along the Belubula River between Millambri and Cranky Rock, the Millambri Formation conformably succeeds the Rockdale Formation, and it is at least in part a correlative of the Late Ordovician Angullong Tuff. In this area the age of the upper part of the formation is not known. The succession is overlain with apparent disconformity by the Silurian Cudal Group.

Mitchell Breccia

(48)

An unfossiliferous succession of conglomerates and tuffs of andesitic derivation. From its relationships conformably beneath the Hensleigh Siltstone (Wolf et al., 1968), the formation is assumed to have an early Bendigonian or Lancefieldian age. See also discussion of Fairbridge Volcanic Group.

Mithaka Formation

(10)

The Mithaka Formation lies in conformity with the underlying Carlo Sandstone and overlying Ethabuka Sandstone, although Draper (1977) has argued that it may be an inshore lagoon-bay facies laterally equivalent to an active island barrier (Carlo Sandstone) with quieter subtidal deposits (Nora Formation) offshore. The varied, undescribed shelly fauna has a Middle Ordovician aspect (Shergold et al., 1976). It includes large asaphid trilobites up to 300 mm in length, large nautiloids several metres in length, other molluscs, brachiopods, bryozoans, ostracods, Receptaculites and sponge spicules (Draper, 1977). The trace fossil occurrences include Rusophycus and Diplocraterion (Draper, 1980a).

Moina Sandstone

(20, 21)

First called the Moina Pipestem Sandstone, this unit is a sandstone containing abundant worm burrows perpendicular to the bedding. It overlies the Roland Conglomerate near Moina (long. 146°04.8'E, lat. 41°29.3'S) and is overlain in a number of places, e.g. near Mole Creek, by the Gordon Sub-group (Column 21). Sandstones in this stratigraphic position just west of Chudleigh (long. 146°28.5'E, lat. 41°33.1'S) contain Tritoechia sp. and sandstone very close to the top of the unit at the Grunter on the southern side of Standard Hill (long. 146°16.9'E, lat. 41°32.8'S) contains tubicolar burrows, Lecanospira and other gastropods of Early Ordovician aspect.

This name has also been applied to a sandstone (Column 20) containing tubicolar burrows in some horizons which lies conformably above the Mt. Zeehan Conglomerate (part of Denison Sub-group, q.v.) and conformably below the fine-grained clastic and carbonate sediments of the Gordon Sub-group in the Zeehan area of Western Tasmania (Blissett, 1962). This

sandstone contains sparse marine fossils and is up to 600 m thick.

Mona Vale Siltstone

(49)

In its revised and emended form, the Oakdale Group (Vandyke & Byrnes, 1976) includes only the Ordovician (the lower) part of Strusz's (1960) Oakdale Formation. It comprises the Mona Vale Siltstone and the underlying Cypress Hill Volcanics, and is unconformably overlain by the Silurian Dripstone Group. Graptolites of Late Ordovician (Eastonian) age have been recorded (Strusz, 1961; Packham, 1969, p.82). Occurrences of Shumardia and Geragnostus? suggest a slightly older, possibly Gisbornian age (Webby, 1973; 1974). Coccoseris speleana is also reported from a limestone lens (Vandyke & Byrnes, 1976), and is a diagnostic element of coral/stromatoporoid Fauna I (Webby, 1969).

Mootwingee Group

(16)

See discussion of constituent formations, the Nootumbulla Sandstone, the Bynguano Quartzite and the Rowena Formation.

Mort Member

(11)

See discussion of Ninmaroo Formation.

Mount Chandler Sandstone

(12)

Wilson (1952) informally referred to the 'Mt. Chandler quartzites' and considered them to be most likely of Ordovician age. Coats (1963) formally named them as the Mount Chandler Sandstone, and implied that three separate units belonged to the formation - lower and upper sandstones separated by a middle, shale-siltstone unit (see also Wopfner, 1969, p.111). Krieg (1973) restricted the definition of the formation to the lower sandstone unit. In terms of Krieg's (1973) emended definition, it comprises a 100 m thick, well sorted, cross-bedded, quartz sandstone succession. Much evidence of organic activity, especially a large variety of Diplocraterion, and Skolithos, is exhibited. The formation has been correlated on lithological grounds with the Pacoota Sandstone of the Amadeus Basin (Krieg, 1969, Wopfner, 1969), but may be much younger.

Mount Dijou Volcanics

(43)

See discussion of Ballast Beds.

Mount Easton Shale

(27, 29, 30?)

This black shale unit (Baragwanath, 1925; VandenBerg, 1975) is preserved as a series of large and small fault slices with rich graptolite faunas ranging from Darriwilian to early Bolindian (Column 27). The best-known Darriwilian fauna, in a small fault slice near Enoch's Point, is a Da3 assemblage comprising Isogr. cf. forcipiformis, Cardiogr. crawfordi, Holmogr. spinosus, H. lentus, Pseudotrigonogr. ensiformis, and Diplogr.? decoratus (Harris & Thomas, 1942). Gisbornian faunas of the N. gracilis Zone are known from Enoch's Point (Harris & Thomas, 1942); from a newly discovered locality in Deep Creek east of Walhalla; and from drill cores at Phosphate Hill. The rich Phosphate Hill fauna includes Didymogr. sp., Nicholsonogr.? sp., Glossogr. hincksi, Nemagr. spp., Dicellogr. sextans, D. intortus, Glyptogr. sp., Climacogr. brevis, C. riddellensis, Reteogr. geinitizianus, and Orthoretiolites? speciosus (VandenBerg, 1979b). The presence of Nicholsonogr.? and O.? speciosus are interesting - the former has not been recorded from Victoria before, and the latter has hitherto only been recorded from uppermost Darriwilian beds. The section between Enoch's Point and Mount Matlock contains a complete early Eastonian (Ea1) to late Bolindian graptolitic sequence. Faunas of late Eastonian and early Bolindian age are present in drill cores from Phosphate Hill.

The formation is preserved as small fault slivers within and flanking the Cambrian rocks of the Mount Wellington Belt (Column 29). The oldest fauna, at Howqua River, comprises Isogr. 'caduceus', Holmogr. spinosus, Pseudotrigonogr. ensiformis, Paraglossogr. tentaculatus, and Glossogr. cf. acanthus, indicative of Da3 age (Harris & Thomas, 1938b). Graptolites of Zone Da4 are not recorded. The faunas of the Upper Ordovician portion of Mount Easton Shale at Wellington River are the richest, most diverse, and best-preserved in Victoria, and form the basis for much of the revised zonal scheme summarized in Part 2 (Victorian stages and graptolite zones) and Fig. 2. They range from the early Gisbornian

Zone of N. gracilis to the late Bolindian Zone of D. ornatus and C. latus.

A narrow belt of black shale with some interbedded sandstone in the Upper Howqua River is flanked on both sides by Hotham Beds (Column 30). The contacts are probably faulted. It contains one of the best-known Da4 faunas, comprising Isogr. ovatus, Glyptogr. teretiusculus, and Climacogr. riddellensis (Harris & Thomas, 1938b). Another locality nearby contains Diplogr.? decoratus together with Glyptogr. intersitus, indicating an age close to the Da2-Da3 boundary. Shales outcropping a few km farther south contain a rich early Gisbornian fauna, with Didymogr. sp., Nemagr. gracilis, N. cf. exilis, Dicellogr. sextans, Jiangxigr. mui, Cryptogr. tricornis, Diplogr. n. sp., Pseudoclimacogr. cf. scharenbergi, and Reteogr. geinitzianus.

Mount Peel Beds

(60)

In the Mount Peel area, near Cobb Valley, limestone equated with Summit Limestone is overlain with a possible tectonic or unconformable contact, by graptolite-bearing phyllitic siltstone and sandstone, the 'Mount Peel Bands A and B' of Keble & Benson (1929) and Skwarko (1962). The graptolites are poorly preserved and little known but have been taken to indicate a 'middle' Gisbornian age by Keble & Benson (1929) and Skwarko (1962).

Mount Pleasant Andesite

(50)

This volcanic unit is inferred to be a lateral correlative of the Walli Andesite (Smith, 1969; Webby, 1976). It has conformable relationships with the 'Malongulli Formation' of Smith above, and possibly with the underlying Sunny Ridge Beds below. Judging from its relationship beneath the 'Malongulli Formation' of Smith, the Mount Pleasant Andesite has a mainly pre-Darriwilian age (Smith, 1966).

Mount Windsor Volcanics

(58)

See discussion of Cape River Beds.

'Munda sequence'

(12)

Informal grouping introduced by Krieg (1973) to include the Mount Chandler Sandstone, Indulkana Shale, Blue Hills Sandstone and Cartu Beds of the eastern Officer Basin. Age uncertain, but on lithological grounds, it has been correlated with the Larapinta Group of the Amadeus Basin. Given the absence of age-diagnostic fossils, the sequence may be either of Early-Middle Ordovician, or Siluro-Early Devonian, age.

Nambeet Formation

(2)

This predominantly shale succession, with minor, thin interbedded limestones and sandstones grades downward into a basal sandstone unit. Locally developed conglomerates may occur at the contact with the underlying Precambrian basement granites. The formation is overlain by carbonates of the Willara Formation. A rich and varied fauna is known (Gilbert-Tomlinson in Johnstone, 1961; Legg, 1976; McTavish & Legg, 1976). Legg (1978) has reported the presence of representatives of Faunas 2 and 3a, of Lancefieldian-Bendigonian age. The graptolites Clonograptus and Adelograptus occur in the Fauna 2 assemblage, and Tetragr. fruticosus (4br.), Didymogr. latus, D. similis and Goniogr. thureau, in the Fauna 3a assemblage. Conodont 'zones' OCA-OCC (McTavish & Legg, 1976) and the microfloral 'zones' 01-02 (Combaz & Peniguel, 1972) are also recorded from the formation.

N'Dahla Member

(8)

See discussion of Pacoota Sandstone.

Nelungaloo Volcanics

(44)

Sherwin (1979b), based on the finding of Didymogr. (Cymatogr.) sp., suggested a Bendigonian age for an unnamed unit of siltstones and sandstones immediately overlying the andesitic Nelungaloo Volcanics.

New Country Creek Sandstone

(31)

This basal unit of the Yalmy Group is only known from New Country Creek, where it

overlies the Warbisco Shale. Rare thin black siltstone beds near the base of this 400 m thick sandstone unit contain late Bolindian graptolites (Dicellograptus ornatus, Paraorthograptus pacificus). The upper part, from which no fossils have yet been collected, may extend into the Silurian. Middle Llandovery graptolites have been obtained from the upper units of the thick Yalmy Group.

Nine Mile Volcanics

(34)

This succession is composed of high potassium porphyritic basalts and tuffs with minor interbedded shales and cherts. The Nine Mile Volcanics are shown by Owen & Wyborn (1979) to have a diachronous lower boundary, and to intertongue with the upper part of the Temperance Formation. They are overlain unconformably by the Silurian Tantangara Formation. Sherrard (1954) has recorded a Gisbornian graptolite assemblage from the upper part of the succession, including such elements as Glyptogr. teretiusculus, Pseudoclimacogr. scharenbergi, Dicellogr. divaricatus salopiensis and Reteogr. geinitzianus. The solitary rugose coral from the upper part of the sequence (Legg, in Owen & Wyborn, 1979) is likely to have come from an horizon no older than the level of the coral/stromatoporoid fauna I of Webby (1969).

Ninmaroo Formation

(10, 11)

This richly fossiliferous carbonate sequence has a widespread distribution in the southeastern part of the Georgina Basin. Of the faunas, only the conodonts (Druce & Jones, 1971) rostroconchs (Pojeta et al., 1977) and trilobites (Shergold, 1975) have been adequately described. In the type area of the Burke River Structural Belt, the boundary of the Ninmaroo Formation with the underlying 'Chatsworth Limestone' is diachronous, spanning the Cambrian/Ordovician boundary. From north to south, the base of the Ninmaroo Formation rises, from a late Payntonian to an early Datsonian horizon (Jones et al., 1971), with the consequence that at Dribbling Bore, even the top of the underlying 'Chatsworth Limestone' exhibits conodonts of the Cordylodus proavus Assemblage Zone (early Datsonian). The top of the Ninmaroo Formation lies just above the Warendian-'Arenig' boundary. Shergold & Druce (1980) have divided the formation into five members - the Unbunmaroo Member (late Payntonian-early Datsonian), the Jiggamore Member (middle-late Datsonian), the Mort Member (early Warendian), the Corrie Member (middle Warendian) and the Datson Member (late Warendian-earliest 'Arenig'). Shergold et al. (1976) have viewed the Swift Formation as a silicification alteration product of the Corrie and Datson Members.

In the Toko Range area, a thicker (1100 m) sequence of Ninmaroo Formation is developed, ranging from Payntonian to mid-Warendian. It is overlain conformably by the Kelly Creek Formation. Further west, in the Tarlton Downs area, the formation interfingers with the thinner, more sandy succession of Tomahawk Beds (Shergold et al., 1976).

Nita Formation

(2)

The Nita Formation is a unit of limestones with minor interbedded dolomites and shales, with a restricted development in the west-central part of the Canning Basin. It has been shown by Legg (1978) to be laterally equivalent to the upper part of the 'shaly' Goldwyer Formation. Each contains representatives of Legg's (1978) Fauna 6, of probably middle-late Darriwilian age. No faunas have been described from the unit. The Nita Formation is overlain with apparent disconformity by the Silurian Carribuddy Formation (McTavish, in Playford et al., 1975). McTavish (in Playford et al., 1975) has also noted that the Roebuck Dolomite of McWhae et al. (1958) is a correlative of the Nita Formation.

Nootumbulla Sandstone

(16)

Resting unconformably on the Middle Cambrian Coonigan Formation, the Nootumbulla Sandstone comprise a sequence of basal conglomerates, medium grained feldspathic sandstones, and finer, quartz sandstones and siltstones towards the top. Shergold (1971) has recorded saukiid and tsinaniid trilobites from the middle part of the formation suggesting a Payntonian age, and richardsonellinids and leiostegiids from the uppermost part, taken to characterize the early Datsonian. Though relatively poorly fossiliferous, the succession thus appears to span the Cambrian/Ordovician boundary.

Nora Formation

(9, 10)

The Nora Formation has conformable relationships with the underlying Kelly Creek and Coolibah Formations and the overlying Carlo Sandstone. The only known exception is in the

Dulcie Range where Devonian sandstones rest unconformably upon it. Only a small part of the rich Nora faunas - the pelecypods (Pojeta & Gilbert-Tomlinson, 1977) and some nautiloids (Wade, 1977) - have been described. According to Shergold et al. (1976), the trilobite and conodont faunas suggest a middle or middle-late Arenig age. On the other hand, Pojeta & Gilbert-Tomlinson (1977) have noted the mixed, Early and Middle Ordovician aspect of the conodont, trilobite and pelecypod faunas favouring a position close to the Lower/Middle Ordovician boundary. Again, Wade (1977) has commented that the overall aspect of the nautiloids suggest that the Nora Formation has a Chazyan (lower Middle Ordovician) age. Draper (1977) has interpreted the Nora Formation, based on palaeoenvironmental considerations, as a lateral correlative of the Carlo Sandstone and Mithaka Formation, though he still includes the units in strict vertical stratigraphic order as representatives of the Toko Group (Draper, 1980b).

Nungar Beds

(35)

Some areas of outcrop of the Nungar Beds previously mapped as having an Ordovician age have now been demonstrated by Owen & Wyborn (1979) to belong to the unconformably overlying Silurian Tantangara Beds. The revised Nungar Beds are regarded as having an essentially Gisbornian to Eastonian age, being partly equivalent to the Boltons Beds and succeeded conformably by the Adaminaby Beds (Owen & Wyborn, 1979). However, in view of recorded Eastonian graptolite occurrences in the Adaminaby Beds (see previous discussion), it seems likely that an overlapping relationship exists between Nungar and Adaminaby Beds.

Oakdale Group

(49)

See discussion of Mona Vale Siltstone and Cypress Hill Volcanics.

Oceana Limestone

(20)

Outcrops of limestone occur in the vicinity of the shaft head of the former Oceana Mine (long. 145°20'E, lat. 41°55.4'S) and limestone occurs in the (now abandoned) mine. The limestone occurs above the Tubicular Sandstone at the top of the Mt. Zeehan Conglomerate and below the Crotty Quartzite but no contacts have been seen. A core of the limestone contains corals, described by Hill (1955), and other fossils. The corals indicate correlation with the Lower Member of the Benjamin Limestone but recent conodont studies suggest correlation with the Upper Member.

Oolloo Limestone

(5)

Conformably overlying the Jinduckin Formation, this 151 m thick succession of silicified stromatolitic limestones contains a fauna including Lingulella, Apheorthis, Asaphellus, Dactylocephalus and a richardsonellid of 'Tremadoc' aspect (Öpik, 1968). Jones (1971) has given a slightly younger age based on the presence of the 'early Arenig' Drepanodus? gracilis - Scolopodus sexiplicatus conodont Assemblage Zone.

Owen Conglomerate

(20)

The Owen Conglomerate outcrops on Mt. Owen (long. 145°35.7'E, lat. 42°5.5'S) and rests on the Cambrian Tyndall Group. It passes laterally at its base into quartz-wackes containing fossils similar to those in the probably Franconian Singing Creek Formation of the Denison Range (Corbett, 1975). The conglomerate which apparently varies considerably in thickness (see Banks, 1962) has been divided into Lower, Middle and Upper Members. The Middle and Lower Members of the Owen Conglomerate consist mainly of conglomerate and sandstone. The Middle Owen contains sparse ichnofossils of no known value for age determination. The Upper Member comprises the Chocolate Sandstone, the Pioneer Beds and the Tubicular Sandstone. It contains sparse shelly fossils - costate brachiopods, low-spined gastropods and rare trilobites - but these are not well-enough preserved for identification and age determination. In places vertical worm burrows ('Tubicular' bodies) are abundant in the Upper Member. The Upper Member is overlain by the Gordon Sub-group within which are limestones of Blackriveran age. Within the Upper Member is an angular unconformity the temporal duration of which is uncertain (Solomon, 1980; Webby, 1980). The Owen Conglomerate should perhaps be revised to exclude the beds above the unconformity as shown in Column 20. See also discussion of Chocolate Sandstone, Pioneer Beds and Tubicular Sandstone.

Owen Formation

(61)

Calcareous and dolomitic mudstone and sandstone conformably underlie Arthur Marble and Mount Owen (Newman, pers. comm.; Coleman, in press). No fossils are known and age is uncertain. Possible lithostratigraphic correlations are with Units 2 and 3 of the Summit Limestone, which contain sandy and dolomitic beds (the correlation followed here), with Patriarch Formation (Tremadoc - Upper Cambrian) or with Thompson's Flat Formation (Upper Cambrian) of the Springs Junction area (Cooper, 1979a).

Pacoota Sandstone

(8)

The Pacoota Sandstone has mainly conformable relationships with underlying Goyder Formation and overlying Horn Valley Siltstone. One exception is in the north-eastern part of the Amadeus Basin where the Siluro-Devonian Mereenie Sandstone rests unconformably on the separate N'Dahla Member of the Pacoota Sandstone. The formation is considered to range in age from latest Cambrian to early Ordovician - it contains occasional bands of shelly fossils and very conspicuous and abundant occurrences of trace fossils, especially Skolithos. Gilbert-Tomlinson (in Wells et al., 1970, p.66) has recorded three informally designated, stratigraphically distinct faunas - Pacoota I, II and III, corresponding to the latest Cambrian/Payntonian, Tremadoc (?Datsonian-Warendian) and Arenig, respectively (see also Jones et al., 1971). Of the faunas, only the rostroconchs (Pojeta et al., 1977) and the pelecypods (Pojeta & Gilbert-Tomlinson, 1977) have been described. Pojeta et al. (1977) have listed associated trilobites from the Pacoota I (Payntonian) and III (Arenig) levels, and Pojeta & Tomlinson (1977), the first appearance of pelecypods in the 'Arenig' part of the sequence. The N'Dahla Member has a Pacoota II fauna (Wells et al., 1970).

Pander Greensand

(4)

Medium-grained glauconitic and quartz sandstones with the glauconite usually constituting up to 60% of the rock (Kaulback & Veevers, 1969). The maximum preserved thickness is about 183 m. Öpik (in Kaulback & Veevers, 1969) and Jones et al. (1971) placed the Cambrian/Ordovician boundary at the base of the Pander Greensand (see further discussion under Clark Sandstone). The Pander Greensand includes Warendian (middle-late Tremadoc) trilobites, mainly large fragmented asaphids and a 'post-Warendian' (basal Arenig) fauna of asaphids and pliomerids (Shergold, 1971). A rich succession of conodont faunas is exhibited through the Pander Greensand (Jones, 1971). In the lower part the basal Datsonian assemblage zone seems to be missing, but the next two, Oneotodus bicuspatatus-Drepanodus simplex and Cordylodus oklahmensis-C. lindstromi Zones are recorded. In the upper part of the formation all three Warendian assemblage zones are found - Cordylodus prion-Scolopodus, C. rotundatus-C. angulatus and Chosonodina herfurthi-Acodus. There follows the still higher basal 'Arenig' Drepanodus? gracilis-Scolopodus sexiplicatus Assemblage Zone.

Patriarch Formation

(60)

Predominantly of calcareous siltstone and sandstone, the formation contains trilobites, including 'Hectoria' hectori (A. J. Wright, pers. comm.), at several horizons. It conformably underlies Summit Limestone with basal Arenig (late Lancefieldian to Bendigonian) conodonts (Cooper & Druce, 1975). The recent discovery of a conodont-ostracod fauna with Cambrian affinities in the lower beds of the formation (J. E. Simes, pers. comm.) suggests that the base of the formation lies below the base of the Tremadoc.

Pingbilly Formation

(15)

This poorly exposed siltstone and shale succession (member G of Wopfner, 1967) directly overlies the Tabita Formation. It represents the youngest beds preserved in the Mount Arrowsmith inlier. Inarticulate brachiopods are the only fossils recorded from this unit (Warris, 1967, unpubl.)

Pinnak Sandstone

(31)

The oldest rocks in the western part of the belt comprise a thick and monotonous turbiditic sequence of somewhat lithic and felspathic sandstone, siltstone, slate, and rare cherty siltstone. An Early to Middle Ordovician age is inferred from its relationship with the Warbischo Shale.

Pioneer Beds

(20)

This name was applied (Wade & Solomon, 1958, p.383) to chromite-bearing quartzite and conglomerate and other sandstones and conglomerate resting with angular unconformity on the Chocolate Sandstone (long. $145^{\circ}35.6'E$, lat. $42^{\circ}04'S$). With the Chocolate Sandstone the Pioneer Beds comprise the Upper Member of the Owen Conglomerate.

Pipeclay Creek Formation

(54)

A sequence of banded argillites and siltstones, originally mapped as Pipeclay Creek Formation and assigned an Early Devonian age (Crook, 1961), has been demonstrated by Cawood (1976) to underlie an unnamed sequence with Middle Ordovician conodonts (see also notes on Column 54), and to overlie a volcanic-derived sandstone and conglomerate succession containing limestone clasts with a late Middle Cambrian fauna. In an isolated locality near the outcrop of Late Ordovician limestones (Trelawney Beds of Philip, 1966), Packham (1969, p.231) has recorded Didymograptus cf. minutus, suggesting a Bendigonian age. However, this occurrence may alternatively be interpreted as an allochthonous block within the Early Devonian Drik Drik Formation.

Pittman Formation

(36)

The Pittman Formation, originally defined by Öpik (1954) as underlying the Acton Shale, has been revised by Strusz & Henderson (1971) to include, in its upper part, the Acton Shale as a separate member. It is now considered to be the oldest rock unit in the area (Strusz & Henderson, 1971). Öpik (1954), Packham (1969) and Strusz & Henderson (1971) have recorded graptolite associations of Darriwilian (Da3) and Gisbornian ages from the Pittman Formation below the Acton Shale Member, and of late Gisbornian/Eastonian and early Bolindian ages from the Acton Shale Member. Nicoll (1980) described a small conodont fauna from the lower-middle part of the formation. It is dominated by Pygodus servus and Periodon aculeatus aculeatus of Middle Ordovician (Llanvirn) aspect. The Muriarra Formation of Phillips (1956) in the Queanbeyan area is regarded by Strusz (1971) as a continuation of the Pittman Formation.

Prices Creek Group

(1)

See discussion of Emanuel Formation and Gap Creek Formation.

Queenstown Limestone

(20)

A thin, almost vertical sequence of dolomitic limestones and carbonaceous siltstones occurs near Queenstown (long. $145^{\circ}33.2'E$, lat. $42^{\circ}04.5'S$). Corals (Hill, 1955) and cephalopods (Teichert & Glenister, 1953) have been described from this limestone. The coral assemblage suggests correlation with the Lower Member of the Benjamin Limestone. The limestone is probably overlain to the north by carbonaceous siltstones which, east of the Queen River, at approximately long. $145^{\circ}33.5'E$, lat. $42^{\circ}04.5'S$, contain Amplexopora queenstownensis, Stictopora sp. and Amplilichas encyrtos suggesting correlation with the Lords Siltstone and Webby's P. austrina faunule.

Quondong Limestone

(45)

The Quondong Limestone (middle part of the Bowan Park Group) exhibits a diverse and abundant fauna and flora (Semeniuk, 1972). Some of the corals (Hill, 1957; Webby, 1971a; 1972; 1977; Webby & Semeniuk, 1971), the stromatoporoids (Webby, 1969), the bryozoans (Ross, 1961) and the trilobites (Webby, 1971c; 1974) have been described. The assemblage of corals and stromatoporoids in the formation belongs to Fauna II of Webby (1969; 1975). The formation also contains elements of the Pliomerina austrina faunule (Webby, 1974).

Reedy Creek Limestone

(48)

According to Adrian (1971), the Reedy Creek Limestone overlies the Fairbridge Volcanic Group with 'slight disconformity', and is overlain with 'apparent conformity' by a Late Ordovician graptolite succession. The fauna has been listed by Adrian (1971) and Sherwin (1971). Some beds in the lower part of the Reedy Creek Limestone have close lithological and faunal resemblances to counterparts in the Fossil Hill Limestone Member of the Cliefden Caves Limestone. Corals and stromatoporoids of both Faunas I and II have been recorded from

the Reedy Creek Limestone (Webby, 1969; 1975; Webby & Semeniuk, 1971).

Regan's Creek Limestone

(47)

McLean (1974) has described the Regan's Creek Limestone as overlying the Cargo Andesite with probable disconformity, and underlying the Malongulli Formation, though the actual upper contact is not exposed. It has been subdivided by McLean into three members - the lower, thin bedded Ashton Member, the middle, massive Red East Member, and the upper, thin bedded to massive Checkers Member. McLean (1974) listed the fauna and flora of the limestone, and noted the presence of characteristic stromatoporoids and corals of Webby's (1969) Fauna I in the Ashton Member, and his Fauna II in the upper part of the Red East Member and in the Checkers Member. Elements of these faunas have been described (Webby, 1969; 1971a; 1971b; 1972; 1977; Webby & Semeniuk, 1971).

Riddell Grits

(25)

The oldest exposed rocks are represented by a few scattered localities with upper Darriwil (Da3, Da4) faunas. Gisbornian rocks are more widespread, with the best-known sections located along Jackson and Emu Creeks. Thomas & Keble (1933) listed several faunas from the N. gracilis Zone and some that are probably late Gisbornian. The Eastonian part of the Riddell Grits is very sandy and contains mostly impoverished faunas. Diagnostic early Eastonian fossils have not been found, but late Eastonian (Ea3, Ea4) faunas with Dicranogr. nicholsoni, D. hians kirki, Dicellogr. gravis, Orthogr. quadrimucronatus, Climacogr. spiniferus, and C. tubuliferus nevadensis are known from the upper reaches of Konagaderra Creek, from Deep Creek near Bolinda, and from several creek sections near Kerrie.

Rockdale Formation

(46)

Ryall (1965) included in the Rockdale Formation beds formerly regarded as belonging to the lower part of the Millambri Formation (Stevens, 1957a). The formation overlies the Canomodine Limestone with apparent conformity, and is succeeded by beds of the redefined Millambri Formation. The age based on associated graptolites is established as being Late Ordovician (Ryall, 1965; Packham, 1969). Judging from its stratigraphic position overlying the Canomodine Limestone it should perhaps be referred to the early Bolindian.

Rockley Volcanics

(53)

This formation consists of andesite-derived sediments (chiefly fine-grained tuffs and less common conglomerates) with subordinate flows or sills (Stanton, 1956). The volcanics are, according to Packham (1969), underlain and apparently pass laterally into quartz-rich greywackes and slates of the Triangle Group (Bubalahla Formation of Scheiber, 1973). In contrast, Stanton (1956) has noted a sharp upper contact with the Silurian Campbell Group (Bummaroo Formation of Scheibner, 1973). Stanton (1956) has also reported the presence of indeterminate encrinurids and bryozoans in the tuffs, but nothing of age-diagnostic significance.

Roland Conglomerate

(21)

A siliceous conglomerate, Roland Conglomerate, overlies probable Cambrian (including Late Cambrian) rocks with angular unconformity and is overlain by the Moina Sandstone conformably in the area around Mount Roland (long. 146°15.1'E, lat. 41°27.8'S). It may be Late Cambrian, or Early Ordovician or both (Jennings, 1962).

Romsey Group

(23)

It comprises the Lano Gully Sandstone, Stauro Gully Shale, Split Hill Sandstone, Bryo Gully Shale, and Angry Hill Sandstone.

Rowena Formation

(16)

This formation apparently conformably overlies the Bynguano Quartzite and may be subdivided into several distinctive units. The lowest is a basal quartz pebble conglomerate and quartzite unit about 15 m thick, overlain by some 760 m of interbedded quartzites, sandstones and siltstones, with abundant trace fossils including Skolithos. This unit becomes perceptibly more limey and finer grained through its middle part, and contains a

varied shelly fauna. The trilobites include Carolinites, Asaphellus and a Prosopiscus-like form (Shergold, 1971). Inarticulate brachiopods described by Fletcher (1964) also come from this level. Shergold (1971) assigned a middle Arenig age to this horizon. The succeeding 910 m thick sequence comprises predominant quartzites with occasional pebble bands, and also exhibits Skolithos. The formation is overlain unconformably by Devonian Snake Cave Sandstone.

Scopes Range Beds

(17)

The succession may be subdivided into several stratigraphically distinct units. The lowest is a 1220 m thick unit of conglomerates which may be equated with a 'basal' conglomerate of the Nootumbulla Sandstone, of Payntonian or slightly older age. The succeeding 516 m of well bedded quartzitic sandstones contain trace fossils Rusophycus and Skolithos (Rose & Bruner, 1969) and occasional inarticulate brachiopods. They probably correlate with the Bynguno Quartzite of Datsonian-Warendian age. The upper 2000 m of sequence includes lithic and quartzitic sandstones, siltstones and pebbly sandstones, with the trace fossil Arthropycus. This unit probably correlates in general terms with the Rowena Formation of 'Arenig' age.

Shaw Beds

(50)

Unfossiliferous, cleaved and metamorphosed sandstone-siltstone-shale succession with associated basic intrusives and flows; possibly underlying Golden Gully Beds and representing the oldest exposed rocks in the region.

Shaw, Golden Gully and Sunny Ridge Beds

(50)

See separate entries under Shaw Beds, Golden Gully Beds and Sunny Ridge Beds.

Slaty Creek Formation

(59)

Predominantly alternating sandstone and blue grey siltstone with a thick black shale member containing graptolites at several horizons which indicate a Darriwilian age (Cooper, 1979b). Thickness is about 700 m.

Smelters Limestone

(20)

Limestone used in smelting was formerly quarried at both Zeehan (long. 145°20.8'E, lat. 41°55.1'S) and Queenstown (long. 145°33.2'E, lat. 42°04.5'S) and the rock at both quarries has been named 'Smelters Limestone'. As the two occurrences do not cover the same stratigraphic limit, it would be better to give them different names and it is here proposed to restrict use of the term 'Smelters Limestone' to that at Zeehan and use the term 'Queenstown Limestone' (Hill & Edwards, 1941) for that at Queenstown. The Smelters Limestone is faulted against Amber Slate (Silurian) on the west, is probably internally faulted, and is faulted against Crotty Quartzite on the east. In the Smelters Quarry area it is at least 500 m thick. At Grieves Siding, 12 km south-southeast of Zeehan, the basal beds of the limestone contain Blackriveran conodonts.

Sofala Volcanics

(52)

This suite of andesitic rocks is composed principally of volcanic-derived sediments with subordinate flows. It has been subdivided into lower and upper parts, a lower sequence of greywackes, cherts (some containing radiolarians and sponge spicules) and volcanic breccias, and an upper succession of tuffs, volcanic breccias, andesite flows and occasional limestones (in blocks and lenses). A graptolite resembling Glyptogr. teretiusculus has been recorded by Packham (1968; 1969) from the middle of the volcanic sequence and this, together with a conodont fauna and a species of Plasmoporella in limestone boulders of an 'agglomerate' towards the top of the formation (Pickett, 1978), suggests that the Sofala Volcanics is of late Darriwilian or Gisbornian to Eastonian age, possibly even younger considering that the 'agglomerate' fauna is derived. The Sofala Volcanics are overlain unconformably by the Early-Middle Silurian Tanwarra Shale (Barron, 1976; Gilfillan, 1976).

Stairway Sandstone

(8)

This formation rests conformably on the Horn Valley Siltstone. It has been subdivided

by Cook (in Wells et al., 1970; Cook, 1972) into a lower unit of coarse grained quartz sandstones, a middle, variable unit of siltstones, claystones, pelletal phosphorites, thin carbonates and red beds, and an upper unit of fine grained quartz sandstones. Characteristically the lower and upper units exhibit trace fossils, including Skolithos, Diplocraterion, Phycodes and Cruziana. The shelly faunas are diverse and include large trilobites with pygidia up to 300 mm across and nautiloids up to one metre long (Cook, 1972). Only the vertebrates (Ritchie & Gilbert-Tomlinson, 1977) and the pelecypods (Pojeta & Gilbert-Tomlinson, 1977) have been adequately described. The age of the Stairway Sandstone is given by Ritchie & Gilbert-Tomlinson (1977) as no younger than early Middle Ordovician (late Arenig to early Llanvirn), and by Pojeta & Gilbert-Tomlinson (1977) as no older than early Middle Ordovician (Llanvirn-Llandeilo), that is, limiting the age to the Llanvirn (probably the early Llanvirn).

Stauro Gully Shale (23)

Apart from the La1 fauna, of which it is the type stratum, the unit (VandenBerg & Wilkinson, in prep.) contains the phyllocarid Caryocaris stewarti and the new arthropod genus Corcorania (Cooper & Stewart, 1979; Jell, 1980).

Split Hill Sandstone (23)

The formation (VandenBerg & Wilkinson, in prep.) contains phyllocarids but lacks any age-determining fossils.

Stokes Siltstone (8)

Succeeding the Stairway Sandstone with conformity is a sequence comprising interbedded fossiliferous, calcareous siltstones and limestones (often coquina-like) in its lower half, and green and red siltstones and shales (some exhibiting pseudomorphs after halite) in its upper half. The varied shelly fauna which is confined to the lower half remains inadequately known. A few pelecypods have been described by Pojeta & Gilbert-Tomlinson (1977) and the bryozoan Batostoma has been recorded (Crockford, 1943; Ross, 1961). Brachiopods such as Dinorthis and Hesperorthis suggest an early Middle Ordovician age (G. A. Cooper, in Pojeta & Gilbert-Tomlinson, 1977).

Summit Limestone (60)

Dark lenticular limestone (Unit 1) with conodonts of the Drepanodus? gracilis - Scolopodus sexplicatus Zone pass up into pale sandy, and partially dolomitised limestone (Units 2 and 3) with conodonts, including Acodus deltatus. Age for Units 1-3 therefore ranges from basal Arenig (late Lancefieldian) to early Arenig (about Bendigonian). Conodonts of middle Llanvirn age from the top of the formation at Mount Mytton (J. E. Simes, pers. comm.) indicate that the formation ranges up to the Late Darriwillian. Minimum thickness is 370 m.

Sunny Ridge Beds (50)

Sequence of unfossiliferous, medium to coarse, feldspathic sandstones with minor siltstones and intraformational conglomerates, about 1100 m thick and underlying apparently conformably the Mount Pleasant Andesite.

Swift Formation (11)

Öpik (1960) and Smith (1972) regarded the Swift Formation as a separate unit lying unconformably on the Ninmaroo Formation. In contrast, Shergold et al. (1976) and Shergold & Druce (1980) interpreted the unit as a weathering product of the upper part of the Ninmaroo Formation, laterally equivalent to the Corrie and Datson Members. The unit includes a varied fauna, including an occurrence of Sigmagr. latus, suggesting a Bendigonian age (Skwarko, 1967). See also discussion of Ninmaroo Formation.

Tabita Formation (15)

Described as Member F of Wopfner (1967), the Tabita Formation has conformable relationships above and below, and comprises a sequence of interbedded limestones and silty shales with a varied, though as yet undescribed, shelly fauna. Shergold (1971) has noted

the occurrence of Pseudobasilicus, 'Asaphellus', Tasmanocephalus, Carolinites and representatives of the Richardsonellinae and Protopliomerinae, forms which suggest a correlation with the lower half of the Rowena Formation of the Bynguano Range and the Horn Valley Siltstone of the Amadeus Basin. Warris (1969) outlined a three-fold zonal scheme based on the conodont assemblages ranging in age from early to late Arenig. Jones et al. (1971) suggest a narrower, middle to late Arenig, age based on the conodont faunas.

Tallebung Group

(43)

In the Tallebung area there is a Late Ordovician succession of slates interbedded with subordinate sandstones and quartzites. Sherrard (in Rayner, 1969) has identified Climacogr. bicornis, C. tridentatus, Orthogr. apiculatus and Dicranogr. nicholsoni and other graptolites from the slates. The assemblage establishes a late Gisbornian or early Eastonian age for the unit. The Tallebung Group is unconformably overlain by the Silurian Cobar Group, and intruded by the Erimeran Granite (Brunker, 1968c; 1973). The boundary with the Girilambone Group is faulted, so that the suggested age relationships can only be inferred (see also discussion of Girilambone Group).

Tallong Beds

(40)

Within this tightly folded Late Ordovician quartz-rich greywacke and shale succession, unconformably underlying the Late Silurian Bungonia Limestone, Sherrard (1949) has recorded a varied graptolite fauna, representing four stratigraphically distinct assemblages and having a range from Gisbornian to early Bolindian age (Packham, 1969, pp.85-86).

Temperance Formation

(34)

Owen & Wyborn (1979) have recognized four mappable units within this predominantly chert, tuff and siltstone succession. Other rock types include minor agglomerates and shales. The formation rests conformably on the Boltons Beds and grades up into the Nine Mile Volcanics. It has been established by Owen & Wyborn (1979) that the Dairymans Beds of Stevens (1957b) and Crook et al. (1973) are a correlative of the Temperance Formation. The only known fossils are radiolarians and inarticulate brachiopods of the family Obolidae (Crook et al., 1973; Owen & Wyborn, 1979). The brachiopods have suggested to Crook and others a 'Middle Ordovician' or older age.

Tim Shea Sandstone

(18)

On the crest and northern slopes of Tim Shea (long. 146°28'E, lat. 42°43'S) a formation outcrops which is composed predominantly of red and grey quartz sandstone with minor developments of breccia, red siltstone and conglomerate. This unit, the Tim Shea Sandstone, rests unconformably on Precambrian rocks, is up to 300 m thick and passes conformably up into the Florentine Valley Formation. The grey sandstones are bioturbated and contain some poorly preserved gastropods. The age of the unit is unclear but it is older than the Lancefieldian (La1.5) horizon in the Florentine Valley Formation and may be very Early Ordovician or, more probably, Late Cambrian.

The lithostratigraphic equivalent Reeds Conglomerate is composed of quartzose conglomerate and conglomeratic sandstone overlying the Great Dome Sandstone and underlying the Squirrel Creek Formation in the Denison Range (long. 146°13'E, lat. 42°33'S). It has a maximum thickness of about 1560 m but shows great lateral variations in thickness and was deposited as a series of alluvial fans derived from the Tyennan Geanticline to the west (Corbett & Banks, 1974; Corbett, 1975). Its age is unclear as it has no diagnostic fossils. It is younger than the Franconian Singing Creek Formation and older than the Squirrel Creek Formation which is correlated with the Florentine Valley Formation which includes Lancefieldian (La1.5) graptolites in its middle (Pontoon Hill) member which equates to the siltstone-limestone member of the Squirrel Creek Formation. The conglomerate may be partly Ordovician but is more likely to be Late Cambrian.

Toko Group

(10)

For the history of changes in nomenclature of the Toko Group, see Draper (1980b). Draper has modified the definition of the Toko Group to include the 'sandy' Nora Formation, Carlo Sandstone, Mithaka Formation and Ethabuka Sandstone, and to exclude from the bottom the 'limey' Coolibah Formation. If Draper's (1980b) proposals are to be adopted, the top of the Toko Group will only be recognizable in the subsurface - in the Ethabuka No. 1 Well. The

more traditional grouping of units proposed by Casey (in Smith, 1965) and Smith (1972) is adopted here. Considering that both Coolibah and Kelly Creek Formations have been at various times assigned to the Toko Group, some discussion of the status of the 'sandy' Kelly Creek Formation needs to accompany any proposal to exclude the Coolibah Formation on lithological grounds.

Tomahawk Beds

(9)

The predominantly 'sandy' Tomahawk Beds lie to the north and east of the outcrop of 'limey' Ninmaroo Formation, and are laterally equivalent to it. They rest with disconformity on the Middle-Late Cambrian Arrinthrunga Formation and Meeta Beds and underlie apparently conformably the Kelly Creek Formation (Shergold & Druce, 1980). Of the moderately varied fauna, only the rostroconchs have been described (Pojeta & Gilbert-Tomlinson, 1977). Jones et al. (1971) have recorded pre-Payntonian to Payntonian trilobite faunas and Datsonian conodonts - including the occurrence of Cordylodus proavus - in the Tomahawk Beds. Shergold & Druce (1980) referred to the presence of the late Datsonian Zones of Oneotodus bicuspatatus-Drepanodus simplex and Cordylodus oklahomensis-C. lindstromi from the top of the Tomahawk Beds.

Trelawney Beds

(54)

An isolated, richly fossiliferous, small body of Late Ordovician limestones, occurring in an area previously mapped by Crook (1961) as Early Devonian Drik Drik Formation. It contains a rich conodont fauna of Trenton-Maysville aspect, a level which should be broadly correlative with the Eastonian (Philip, 1966). The corals have been described by Hall (1975) and the assemblage correlated with Webby's (1969) C/S Fauna III. The status of the Trelawney Beds remains in doubt. They may represent in situ limestones, but may alternatively be regarded as allochthonous within the Early Devonian Drik Drik Formation (P.A. Cawood, pers. comm.).

Triangle Group

(53)

See discussion of Bubalahla Formation and Burra Burra Creek Formation.

Tubicolar Sandstone

(20)

This name has been applied to a quartzite or sandstone containing abundant vertical worm burrows similar to Arenicolites and/or Monocraterion and Skolithos (Twelvetrees, 1907). The unit has also been called 'pipestem sandstone' and, locally, Moina Sandstone. Rocks of this lithology occur at the top of or over Late Cambrian and/or Early Ordovician conglomerates such as the Owen Conglomerate, Mt. Zeehan Conglomerate or Roland Conglomerate and others and below the Gordon Sub-group. In the Queenstown area the tubicolar bodies occur in the topmost unit of the Chocolate Sandstone and in the Pioneer Beds.

Uralba Beds

(55)

Hall (1975) introduced the name for a sequence of cherts and mudstones with associated limestone lenses, situated within the Peel Fault System. Faulted contacts occur at both the top and bottom of the unit. Hall has described a varied, Late Ordovician coral fauna from the limestones. Elements of Webby's (1969; 1975) coral/stromatoporoid Fauna IIIb are represented - for instance, abundant Favistina and Palaeophylum, Plasmoporella inflata, favositids and halysitids (including Catenipora). The fauna, except for the halysitids, is similar to that in the Trelawney Beds, and may be of comparable or slightly younger age.

Unbunmaroo Member

(11)

See discussion of Ninmaroo Formation.

Wagonga Formation

(41)

Wilson (1969) and Chalker & Bembrick (1975; 1977) have mapped separate volcanic (intermediate-basic lavas, breccias and tuffs) and chert facies of the Wagonga Formation. It is conformably underlain by the Bogolo Formation and, according to Etheridge et al. (1973), apparently conformably overlain by a greywacke-slate unit of probable Late Ordovician age. Late Ordovician (Gisbornian or Eastonian) graptolites have recently been found in

black shale bands of the chert succession (Kidd, 1975, unpubl.).

Walli Andesite

(47)

Rock types are predominantly porphyritic andesite and fine-grained vesicular basalt lavas, with subordinate, interbedded volcanic breccias and tuffs, especially towards the top of the succession. The basalts may show pillow structures (Smith, 1967). The sequence is overlain with probable angular unconformity by the Cliefden Caves Limestone (Smith, 1968, Fig. 1D).

Wangapeka Formation

(61)

A lithologically varied assemblage of alternating sandstone and shale, graded sandstone, black shale, and quartz sandstone. Graptolites are known from several horizons and indicate the Eastonian stage. Age of the base of the unit is uncertain and it is possible that, at some localities, the formation is separated from underlying Arthur Marble 1 by disconformity. Age of the upper boundary is also uncertain, the upper part of the unit apparently being the lateral equivalent of Arthur Marble 2. In the Wangapeka Valley, opposite Gibb Stream, Wangapeka Formation passes gradationally up into quartz sandstone of the Hailes Quartzite (Coleman, in press) but at Flora Saddle it passes up into Arthur Marble 2. The base of the Hailes Quartzite is arbitrarily taken as the base of the Silurian (Cooper & Wright, 1972) leaving a relatively long interval (according to the time scale adopted for the chart) to be filled by Wangapeka Formation. However, no complete stratigraphic sections extending from Arthur Marble 1 to Hailes Quartzite have been described and continuity of deposition through this interval is by no means certain. Thickness is at least 600 m.

Warbisco Shale

(31)

Overlying the Pinnak Sandstone is a distinctive unit of about 300 m of black pyritic shale and rare clean sandstone with a basal thin phase of chert and siliceous shale. This basal portion contains an impoverished fauna of the early Gisbornian N. gracilis Zone, but the remainder is very richly graptolitic, with faunas ranging from late Gisbornian to late Bolindian (see Part 2, Victorian stages and graptolite zones).

Webb Formation

(59)

A thick succession of alternating quartz-rich micaceous sandstone and mudstone forms the lowest unit of the Aorangi Mine sequence (Bishop, 1968; Cooper, 1979a). Age diagnostic fossils are lacking. Because the unit conformably underlies the Aorangi Mine Formation (Lancefieldian to Yapeenian) it is thought to be of Late Cambrian to basal Ordovician age. It is also thought to be equivalent to the Greenland Group of Southwest Nelson and Westland.

Westfield Sandstone

(18)

This formation was proposed as Westfield Beds by Corbett & Banks (1974) for the siltstone and sandstone unit above the Benjamin Limestone in the Florentine Valley (long. 146°29.9'E, lat. 42°39'S). At the time of the proposal of the formation and name no top could be delineated due to lack of access to the Tiger Range. Subsequently, Baillie (1979) was able to show that the formation is about 250 m thick, is predominantly sandstone and is overlain by the Gell Quartzite of the Tiger Range Group. He proposed the name Arndell Sandstone for the formation but 'Westfield' has priority and can be applied to the unit without engendering confusion. Near the base a trinucleid (cf. Guandacolitus) suggests an Ordovician age and is associated with a synhomalonotid (cf. Calymene birmanica) and Glossograptus sp. Higher horizons are also richly fossiliferous and include one horizon containing graptolites of the Early Llandovery persculptus or acuminatus Zones (Baillie et al., 1978). The lowest fossil horizon recognised in the overlying Tiger Range Group, about 230 m above its base, contains graptolites of very Late Llandovery age (crenulata or griestoniensis Zones) (Baillie, 1979).

Willara Formation

(2)

Introduced by McTavish, in Playford et al. (1975) to replace the invalidly named 'Thangoo Limestone' of Elliott (in Pudovskis & Willmott, 1961), the Willara Formation has its type section in the Willara No. 1 Well. It has conformable relationships with both the underlying Nambeet and overlying Goldwyer Formations, and contains a rich fauna of

Middle-late Arenig aspect (McTavish & Legg, 1976). Legg (1978) has assigned the basal part of the Willara Formation to Subfauna 3c on the basis of occurrences of Nambeetella, Tetragraptus and the influx of phyllograptids. The graptolites of this subfauna suggest a correlation with the late Bendigonian (Legg, 1978). McTavish's (in McTavish & Legg, 1976) conodont 'Zone' OCD with Prioniodus evae communis is also associated. Combaz & Peniguel (1972) assigned the microflora of the Willara Formation to the Zone of Conochitina langei.

Wilson Cliffs Sandstone

(3)

The Wilson Cliffs Sandstone includes the 'Lower Formation' and 'Middle Formation' of Creevey (1971). In the type succession of the Wilson Cliffs No. 1 Well, it rests unconformably on ferruginous shales of ?early Cambrian age, and is overlain conformably by the Goldwyer Formation. Fossils are not common. Legg (1976; 1978) has described Carolinites bulbosa, Phyllogr. anna and Didymogr. bifidus from one horizon. The assemblage is referred to Subfauna 3d, of slightly younger age than Subfauna 3c, and probably correlating with the Chewtonian of Victoria (Legg, 1978).

Yalmy Group

(31)

See discussion of New Country Creek Sandstone.

Yandaminta Quartzite

(15)

Typically the Yandaminta Quartzite (Member E of Wopfner, 1967) comprises a lower and upper quartzite with silty shales in between. Fossils include a few poorly preserved Lingula-like brachiopods and the nautiloid Anthoceras. The base is in fault contact with Middle Cambrian sediments, and the top passes up conformably into the Tabita Formation.

Column 13: Pedirka, Warburton Shelf, South Australia

Youngs (1976) referred to the Ordovician in the subsurface beneath the Pedirka Basin as having a widespread extent, with quartzites mainly developed in the west and shales to the south-east. In the Mt. Crispe No. 1 Well, Youngs (1975) recorded Ordovician brachiopods in siltstones of a predominantly quartzitic sandstone succession, tentatively correlated with the Stairway Sandstone of the Amadeus Basin.

Column 14: Dullingari-Gidgealpa, Warburton Shelf, South Australia

Freeman (1963) and Wopfner (1969) indicated that some 774 m of Ordovician sediments - predominantly shales - were intersected in the Dullingari No. 1 Well. Graptolites were recovered from five cores, the lowest two with fragments of uniserial Dichograpti? of Early Ordovician age, and the uppermost with biserial diplograptids suggesting a Middle or early Late Ordovician age (Skwarko, 1967).

Column 17: Dolo Hills, Gnalta Shelf, western New South Wales

At Dolo Hills, a limestone, previously reported by Shergold (1971) as having an Early-Middle Cambrian age from its occurrences of Biconulites and an archaeocyathan, has yielded the conodonts Cordylodus proavus, Oneotodus gracilis and O. datsonensis (P. D. Kruse, pers. comm.). This suggests the presence of either the Oneotodus bicuspatus-Drepanodus simplex or the Cordylodus oklahomensis-C. lindstromi assemblage zone of the Datsonian (Jones et al., 1971). In another locality in the area, Shergold (1971) has referred to the occurrence of a sandstone and quartzite succession with asaphids, dikelocephalinids and protopliomerids, which may be stratigraphically younger (possibly Warendian).

Column 23: Bendigo Sedimentary Belt, Victoria

Except for the Lancefieldian of Lancefield, rocks of the Bendigo Sedimentary Belt have not been subdivided into lithological units. Their total thickness is in the order of 2000 m, and they contain a complete sequence of graptolite faunas ranging from the La2 Zone of A. victoriae to the Da3 Zone of Diplogr.(?) decoratus. The 'typical' localities of all zones of the Bendigonian, Chewtonian, Castlemainian and Yapeenian stages, and of Zones Da1, Da2 and Da3 are located in this sequence. Apart from graptolites, it contains phyllocarids and a few shelly fossils. Lithological details shown in the column are based mainly on mapping of the Chewton Goldfield by Ceplecha (1974), and are assumed to be reasonably representative of the rest of the belt.

Column 24: Heathcote Belt, Victoria

Ordovician rocks of various ages are incorporated as fault blocks and slivers in the Cambrian of the Heathcote Belt. Their lithology and faunas have not been documented, although Thomas (1940, 1941) indicated the presence of graptolites of Zones La2 or La3, Be1, Ch1 to Ya1, Da2, Da3, and of the Gisbornian Zone of *N. gracilis*. The rocks appear to be similar in most respects to those of the Bendigo Sedimentary Belt.

Column 26: Mornington Peninsula, Victoria

Unnamed black shale units occur above and below the Kangerong Sandstone. The black shales of McIlroy's Quarry represent the oldest rocks exposed on the Peninsula. It contains La2 Zone graptolites (Keble, 1950). The black shales of Dunn's Creek Road overlie the Kangerong Sandstone, and from these beds Keble (1950) recorded *Tetragr. acclinans* and *T. decipiens*, regarded as belonging to Zone La3. The 'typical' La3 locality of Harris & Keble (1932) is Bull Dog Creek in the Mornington Peninsula.

The succeeding Lower, Middle and Upper Ordovician strata have not been differentiated. Keble's (1950) map of the Mornington Peninsula suggests that a complete Bendigonian to Castlemainian graptolitic sequence is present, and his text also mentions Yapeenian. The only fossils listed from this interval are index fossils of Zone Be1 from Bull Dog Creek, Balnarring, and Kangerong Hill (Hall, 1904; 1907). The only documented Middle Darriwilian fossils are from Turner's Quarry, which Harris (1935) proposed as one of the 'typical' localities for the now defunct Zone of *Diplogr. (Glyptogr.) euglyphus* (modern Da4). The Da3 Zone fossil *Diplogr.? decoratus* has been recorded from 'northwest of Turner's Quarry' (Harris & Thomas, 1935).

There is virtually no outcrop in the broad band of Upper Ordovician shown on Keble's (1950) map, and the only fossil recorded from it is a '*Climacogr. sp.*' from Langwarrin (Keble, 1925).

Column 28: Waratah Bay, Victoria

In addition to the Digger Island Limestone, there is a little-known outcrop with La3 graptolites, including *T. approximatus*, at Boolarra, completely surrounded by younger rocks (Keble, 1920). The outcrop forms a structural 'high' and may form a northerly extension of the Waratah Bay belt. At Waratah Bay itself, there is no record of graptolitic Lower Ordovician, and richly graptolitic Upper Ordovician rocks near the belt are regarded as part of the Mount Easton Province.

Column 29: Mount Wellington Belt, Victoria

The only occurrence of Ordovician rocks additional to the Howqua Shale and Mount Easton Shale is near Dookie where Thomas (1959) noted the presence of shales with Castlemainian graptolites.

Column 30: Tabberabbera Belt, Victoria

Upper Ordovician rocks in various parts of the Tabberabbera Belt contain too much sandstone to be included in Mount Easton Shale. The most complete fossil record is from structurally complex rocks at Tabberabbera, which contain Gisbornian to late Eastonian graptolites (Thomas, in Talent, 1963). Poorly preserved graptolites of similar age range occur in scattered localities between Cravensville and Wombat Creek near the Gibbo River. Gisbornian graptolites occur in shale and siltstone overlying Darriwilian sandstone in the Lurg Syncline near Glenrowan and Thoona. Bolindian graptolites are known from Goomalibee near Benalla, from Abbeyard in the upper Buffalo River valley, and from Mount Burrowa near Walwa (VandenBerg, 1980b) - this last locality contains a full late Bolindian assemblage.

Column 32: Narrandera-Tarcutta, 'Wagga Metamorphic Belt', south central New South Wales

An extensive area of southern New South Wales and north-eastern Victoria is composed of rocks belonging to the Wagga (or for Victoria, the Omeo) Metamorphic Belt (Packham, 1969; Webby, 1976). The sediments are quartz-rich greywackes, siltstones, slates, cherts and minor conglomerates. In New South Wales the oldest graptolite fauna, an association of dichograptids, glossograptids and diplograptids, has been recorded from chistolite slates south of Narrandera, and suggests a Darriwilian age (Keble & MacPherson, 1941; Sherrard, 1954; Packham, 1969). The remaining graptolite localities listed by Sherrard (1954; 1962) and Packham (1969) are of Late Ordovician (Eastonian) age.

The recent discovery of an assemblage of early Bendigonian graptolites from a locality near Eskdale, north-eastern Victoria (Kilpatrick & Fleming, 1980; see Hotham Beds, Column 30), suggests an earlier start to the depositional history of the Wagga Trough than previously supposed.

Cawood (1976) recorded a sequence of rudites, originally mapped by Crook (1961) as belonging to the lower part of the Drik Drik Formation, which contains conodonts, including Periodon aculeatus, of Middle Ordovician (Llanvirn) age. This fauna is similar to the one occurring in the middle part of the Pittman Formation of the Canberra area (see Nicoll, 1980). The unnamed Middle Ordovician rudites lie unconformably beneath the revised Early Devonian Drik Drik Formation (Cawood, 1976).

5. ORDOVICIAN OF NEW ZEALAND: OTHER AREAS OF OUTCROP
by R. A. Cooper

A. Springs Junction

A sequence of three broad units ranging from Cambrian to Ordovician is preserved in a small block, structurally isolated from other early Palaeozoic rocks near Springs Junction. The lowest unit ('Thompson Flat Formation' of Farmer, 1967) is composed of dolomitic and volcanogenic sandstone, mudstone, conglomerate and rare limestone lenses with Upper Cambrian trilobites (Cooper, 1979b). It is overlain by a limestone unit ('Sluice Box Formation') with Llanvirn and Llandeilo conodonts in its uppermost beds (Simes, pers. comm.). The third unit, dark carbonaceous, strongly cleaved shale and sandstone ('Alfred Formation') contains graptolites (Wellman, 1962) of late Gisbornian or Eastonian age (Farmer, 1967). The upper and lower contacts of the limestone were mapped as conformable by Farmer and it may thus span a considerable period of time. The overall sequence is similar to that of the Central Sedimentary Belt at Mount Mytton, and, probably to the Eastern Sedimentary Belt at Mount Owen.

B. Fiordland

At Chalky and Preservation Inlets in southern Fiordland an Ordovician graptolite-bearing succession (Preservation Formation of Wood, 1960) represents the only New Zealand occurrence of Lower Palaeozoic rocks outside the West Nelson-Westland region. The graptolite sequence and stratigraphy are described by Benson & Keble (1935), and additional species have been added by Skwarko (1958). Graptolites are confined to black carbonaceous shale bands in a sequence of shales, quartzites, and 'greywackes' that resembles the Aorangi Mine Formation (q.v.) of West Nelson. Graptolites range in age from Lancefieldian (La2) to Castlemainian (Ca1) in an unbroken sequence at Cape Providence (Cooper, 1979a). Underlying unfossiliferous rocks are mainly quartzites and 'greywackes' of probable early Lancefieldian age. The rocks pass westwards into regionally metamorphosed chlorite and biotite schists and, locally, near the Kakapo Granite, into biotite and sillimanite schist. Their total thickness is about 1200 m.

6. ORDOVICIAN OF ANTARCTICA - A REVIEW

by P. D. Clarkson, R. A. Cooper, C. P. Hughes, M. R. A. Thomson and G. F. Webers

Diagnostic Ordovician fossils are unknown in Antarctica and the presence of Ordovician strata is yet unproven. However, regional stratigraphy and age-diagnostic fossils from underlying beds suggest that sedimentary sequences in the Bowers Mountains of northern Victoria Land and possibly the Ellsworth Mountains (Fig. 3) are likely to include strata of Ordovician age. The successions in the two areas are comparable and may be more closely similar than present interpretations would suggest. Shallow marine to fluviatile, quartz-rich cross-bedded sandstones (Camp Ridge Quartzite and Crashsite Quartzite, respectively) predominate at both places and overlie fossiliferous Upper Cambrian successions of relatively shallow marine quartz-sandstone, shale and limestone (Mariner Group and Heritage Group, respectively). A marine regression is thus implied in the latest Cambrian or early Ordovician (Andrews & Laird, 1976).

In the Neptune Range of the Pensacola Mountains a sequence with poor age control (Neptune Group) may include rocks of Ordovician age, and Ordovician sequences may also be present in southern Victoria Land and Dronning Maud Land. Supposed Ordovician fossils have been reported from several other areas in Antarctica and the outlying islands; these are briefly reviewed and found to be unsubstantiated.

A major orogenic event, the Ross Orogeny, was accompanied by intrusive magmatism throughout much of the Transantarctic Mountains, and is marked by a cluster of isotopic age determinations in the latest Cambrian to early Ordovician. Intrusive complexes include the Granite Harbour Intrusive Complex of southern Victoria Land, the Hope Granite in the Beardmore Glacier area, the Queen Maud Batholith in the Queen Maud Mountains, the Wisconsin Range Batholith in the Horlick Mountains, and the granite plutons in the Thiel and Pensacola Mountains. In general, an earlier predominantly dioritic intrusive phase is followed by a

later granitic and granodioritic phase.

A. Northern Victoria Land

The Camp Ridge Quartzite (Fig. 4) of the Leap Year Group in the Bowers Mountains is composed of at least 2900 m of remarkably uniform quartzose sandstone and conglomerate with minor amounts of mudstone (Laird et al., in press). It overlies with slight angular discordance the Eureka Formation (Mariner Group), which contains an early post-Idamean (late Cambrian) trilobite fauna in its upper beds (Shergold et al., 1976; Cooper et al., in press). At Camp Ridge the lower part of the quartzite unit contains a trace fossil assemblage including Skolithos, Daedalus, Arthropycus, and Monocraterion (Cooper et al., in press; Laird et al., 1974) but body fossils are unknown. Overlying strata have not been observed but the next youngest strata in the region are those of the Beacon Supergroup (Permian - Triassic in northern Victoria Land). However, Adams, Gabites, Laird et al. (in press) reported a K-Ar whole rock date of 421 ± 3 m.a. (early Silurian) from a red siltstone in the Camp Ridge Quartzite, which presumably represents a metamorphic event and may be taken as an upper age limit for the unit.

Thus, although there is no direct evidence of an Ordovician age for the unit, its age limits are late Cambrian to early Silurian. The trace fossil assemblage, particularly the occurrence of Arthropycus, is consistent with a latest Cambrian or Ordovician age for the lower part, as is its stratigraphical position. It is thus likely that at least the upper part of the Camp Ridge Quartzite ranges up into the Ordovician (Cooper et al., in press; Laird et al., in press).

B. Southern Victoria Land

The Cocks Formation, a mixed sequence of metasedimentary and metavolcanic rocks in the Royal Society Range, may be partly early Ordovician in age (Skinner, in press). It rests unconformably on the deformed limestones and marbles of the (?) early to middle Cambrian Anthill Limestone and, although folded itself, it shows only the last two of the three deformational phases observed in the Anthill Limestone. Constituent andesitic-dacitic volcanic rocks are similar to penecontemporaneous hypabyssal intrusions, and the formation is intruded by post-kinematic granite, gabbro and diorite, which elsewhere have yielded early to middle Ordovician radiometric ages. The tectonic and radiometric constraints placed upon the Cocks Formation by Skinner (in press, table 2) are tight, with deformational, sedimentary/volcanic and intrusive episodes partly overlapping in time. It appears that the formation is latest Cambrian or earliest Ordovician in age.

C. Pensacola Mountains

At least part of the Neptune Group (Schmidt & Ford, 1969) in the Pensacola Mountains may be Ordovician in age. This sequence is best developed in the Neptune Range (Schmidt et al., 1965) but it is also known in Cordiner Peaks and the Forrestal Range (Ford, Schmidt & Boyd, 1978; Ford, Schmidt, Boyd & Nelson, 1978; Schmidt, Williams & Nelson, 1978). The lithostratigraphical units of the strata (Fig. 4) in the Neptune Range were first described by Schmidt et al. (1965) and the Neptune Group itself was defined by Schmidt & Ford (1969). No direct evidence for the age of this group is available, but an age between late Cambrian and Devonian may be inferred from field relationships. Its basal strata (Brown Ridge Conglomerate) rest unconformably on the Wiens and Gambacorta formations, which are assumed to be late Cambrian in age since they in turn rest conformably on the Nelson Limestone, containing late Middle Cambrian trilobites (Palmer & Gatehouse, 1972), and the overlying Dover Sandstone is generally correlated with beds yielding a Middle Devonian flora in the south-western Patuxent Mountains (Schopf, 1968). In the Neptune Range there appears to be no break between the Dover Sandstone and the underlying Neptune Group, although in other parts of the Pensacola Mountains (Ford, Schmidt & Boyd, 1978; Ford, Schmidt, Boyd & Nelson, 1978) there may be a break in the sequence at about this level. Suggestions have also been made that the Heiser Sandstone, the uppermost unit of the Neptune Group, may also be of Devonian age because of its similarity to Devonian rocks in the lower part of the Beacon Supergroup in Victoria Land (Williams, 1969).

Sedimentologically the Neptune Group consists chiefly of well-sorted and well-rounded quartzites very similar to those of mid Palaeozoic sequences elsewhere in Antarctica, although detailed correlation of individual formations is not possible. Indeed it may well be that all of the units of the Neptune Group, with the exception of the Heiser Sandstone, are restricted to the Pensacola Mountains.

It is possible that at least some of the Neptune Group is Ordovician in age. However, it must also be remembered that the underlying Wiens and Gambacorta formations could range up into the Ordovician, or conversely, since the extent of the time gap represented by the pre-Neptune unconformity is unknown, the Ordovician may be absent.

D. Shackleton Range

Inarticulate brachiopods (*Lingulella*(?) sp.) from moraine near Mount Provender, western Shackleton Range were thought to be Cambro-Ordovician in age (Thomson, 1972). Although not known in situ, these are believed to be derived from an unexposed part of the Blaiklock Glacier Group nearby, and thus the possibility of there being Ordovician rocks in the area arises. However, Soloviev & Grikurov (1978; 1979) have demonstrated, on the basis of newly discovered trilobites in the same morainic material, that these sediments are of Cambrian age, a conclusion supported by Clarkson et al. (1979).

E. Kirwanveggen, Dronning Maud Land

The Urfjell Group, a thick (+1650 m) sequence of mainly quartzites and conglomerates in Kirwanveggen, was tentatively correlated with the Blaiklock Glacier Group of the Shackleton Range and the Neptune Group of the Pensacola Mountains (Aucamp et al., 1972). In the first instance a (?)Cambrian age is implied, but in the second an Ordovician age is possible. With no fossil evidence for the age of the rocks in Kirwanveggen and the uncertainties associated with the supposed correlations, further comment is unwarranted at present.

F. Ellsworth Mountains

The Crashsite Quartzite Formation (Fig. 4) of the Ellsworth Mountains is estimated to be at least 3200 m thick (Craddock, 1969). It consists almost entirely of quartzite with minor amounts of argillite and clay-pebble conglomerate. At Webers Peaks in the northern Heritage Range it rests conformably on beds of the Cambrian Heritage Group, containing an earliest Franconian (late Idamean to early post-Idamean) trilobite-mollusc fauna (Webers, 1970; 1972). The recent discovery of Cambrian trilobites in the Minaret Formation [Group] indicates that it may correlate with the upper part of the Heritage Group, and it is not Precambrian as was previously believed (Craddock, 1969).

In the Sentinel Range the Crashsite Quartzite exhibits a three-fold division into a lower dark member, a middle light member, and an upper dark member; virtually continuous exposures incorporating all three divisions are present. Exposures in the Heritage Range are more discontinuous but, at an isolated locality near Planck Point, a Devonian brachiopod fauna has been recovered (Boucot et al., 1967) from strata correlated on lithological grounds with the upper dark member. More recent collecting at an adjacent locality has produced poorly preserved molluscs, a trilobite pygidium and a vertebra. The only other fossils known from the formation are a few indeterminate inarticulate brachiopod fragments and trace fossils. Assuming that there is no undetected sedimentary break between the Heritage Group and the Crashsite Quartzite, the lower parts of the quartzite sequence should include strata of Ordovician and Silurian age. If so this represents a unique sedimentary sequence in Antarctic geology. It is significant that, without prior information on the strata, Professor A. Seilacher (pers. comm. to C. Craddock, 1964) identified trace fossils from the Crashsite Quartzite of the Sentinel Range as Ordovician types.

G. South Orkney Islands

Supposed Ordovician-Silurian fossils were reported from Graptolite Island, near Laurie Island by Pirie (1904; 1905) in a sequence of greywackes and shales, now known formally as the Greywacke-Shale Formation (Thomson, 1973). He collected three poorly preserved fossils, one of which was subsequently identified as *Pleurograptus* by G. L. Elles (cf. Pirie, 1905, p.466), and the other two as *Discinocaris* (cf. Peach in Pirie, p.469). Further specimens from outcrops of the same formation at the nearby Cape Dundas, Laurie Island, were described by Cordini (1955, pp.273-277, figs. 80-82) as ?*Dicellograptus*, ?*Conularia*, and some plant fragments. He suggested that these limited the age of the Greywacke-Shale Formation to the Ordovician. Doubt was cast on Pirie's fossils by Wilckens (1933) who considered them as inorganic. Furthermore Strachan (in Adie, 1957, p.22) considered that the specimens, which are extremely poorly preserved, provide no positive evidence for an Ordovician-Silurian age and could equally well be identified as plant fragments and assigned a Carboniferous age. These specimens, which are now housed in the Royal Scottish Museum (RSM 1954.2.28, 1954.2.29), have been re-examined by Dr. R. B. Rickards and Professor W. G. Chaloner. Rickards believes that the specimens identified by Elles as *Pleurograptus* could be a graptolite but, since no thecal structures are preserved, it is impossible to be certain. Chaloner believes that none of the specimens are of plant material. The specimens originally identified as *Discinocaris* may well be arthropod remains. Recent attempts to extract microfossils from the Greywacke-Shale Formation of Graptolite Island have proved unsuccessful. It is difficult to make a well-founded comment on the Cape Dundas specimens collected by Cordini and to substantiate his identification of ?*Dicellograptus* from his fig. 80.

Despite this uncertainty over the fossil evidence from the Greywacke-Shale Formation, some authors continue to consider it as early Palaeozoic, or even specifically Ordovician age (Cordini, 1959, pp.154, 157; King & Downard, 1964, p.729; Kobayashi, 1971, p.235). However, the presence of vascular plant remains at Cape Dundas (Cordini, 1955, fig. 82) and on nearby Fredriksen Island (Dalziel et al., in press) suggests a post-Ordovician age for at least part of the Greywacke-Shale Formation. Current understanding of the lithology and structural history of the Greywacke-Shale Formation (Dalziel, in press; Smellie, in press) favours a correlation with the late Palaeozoic - early Mesozoic Trinity Peninsula Formation of Graham Land, as was first suggested by Adie (1957, p.22). A massive chert forming Scapa Rock, which may be part of the Greywacke-Shale Formation, has recently yielded a small fauna of Triassic Radiolaria and a conodont (Dalziel et al., in press).

H. South Georgia.

Poorly preserved problematic fossils from the 'lower division of the Cumberland Bay Series', collected by D. Ferguson from between Leith and Nansen harbours, were identified by Gregory (1914; 1915) to be early Palaeozoic forms. He identified a coral, supposedly allied to *Omphyma*, some sponges (one tentatively assigned to *Camarocladia*?), and the trace fossil *Buthrotrephis* [= *Chondrites*], together with a supposed possible monoprionid graptolite fragment (Gregory, 1915, p.819). A number of Radiolaria from the 'middle division of the Cumberland Bay Series' at Cape Pariadin, identified by G. J. Hinde as Mesozoic types, were also listed. However, Gregory deduced an Ordovician-Silurian age for the lower division. Hinde's identifications of the Radiolaria were subsequently endorsed by Wilckens (1932), who also suggested that Gregory's (1915) Palaeozoic fossils were flysch-type trace fossils such as are known in Cretaceous deposits elsewhere. A record of *Dadoxylon* (*Araucarioxylon*) from the sequence (Gordon, 1930) suggested an age no older than Carboniferous.

Recent reviews of geological, palaeontological and radiometric data from the Cumberland Bay Formation (Tanner, in press; Tanner & Rex, 1979; Thomson et al., in press) all indicate that the whole of the formation is of latest Jurassic - early Cretaceous age. It is believed that Gregory's identifications were all erroneous and that there is no evidence to suggest that any Ordovician rocks are present in the Cumberland Bay Formation of South Georgia.

I. Ross Orogeny

Throughout the Transantarctic Mountains the late Precambrian to early Palaeozoic sedimentary sequence and intrusive igneous rocks are overlain with angular and metamorphic discordance by sedimentary rocks of the Beacon Supergroup (Devonian to Triassic) or their equivalents. These relationships indicate a widespread deformational event, postdating Middle-Upper Cambrian sedimentation by antedating the Devonian. Intrusive calc-alkaline rocks of this age are widespread (see below) and the intrusive-deformational events are marked by a cluster of radiometric dates (references cited by Elliot, 1975; Adams, Gabites, Laird et al., in press; Adams, Gabites & Grindley, in press, Fig. 1).

The intrusive-deformational episode is known as the Ross Orogeny (Gunn & Warren, 1962; Grindley & Warren, 1964) and it is now generally ascribed to the latest Cambrian to early Ordovician, although some workers have used the term to include events ranging in age from middle Cambrian to late Ordovician. It should be noted that a second event, the Borchgrevink Orogeny of Silurian age, deformed rocks in northern Victoria Land prior to the deposition of the Beacon Supergroup (Bradshaw et al., in press).

Deformation and metamorphism appear to have been most intense in southern Victoria Land (references cited by Elliot, 1975). In northern Victoria Land, on the other hand, an 'orogeny' is scarcely recognizable, apart from the emplacement of the Granite Harbour Intrusive Complex. Middle to Upper Cambrian sedimentary rocks of the Mariner Group were gently tilted; uplift and cooling are indicated by rejuvenation of the source area of the Leap Year Group sedimentary rocks and by the widespread K-Ar dates of 447-499 Ma (Bradshaw et al., in press). In the Ellsworth Mountains (not part of the Transantarctic Mountains) the Cambrian to Devonian sequence is apparently conformable with no evidence of the Ross Orogeny or an equivalent event (Craddock, 1969).

J. Ordovician magmatism in Antarctica

Magmatism in Antarctica during the Ordovician was probably confined to Greater Antarctica and, very largely, to the Transantarctic Mountains where plutonic rocks associated with the Ross Orogeny are exposed. Ordovician igneous rocks have not been reported from Lesser Antarctica although Ordovician radiometric ages have been reported from undifferentiated basement complex metamorphic rocks of Thurston Island and the Ruppert Coast (Fig. 1, Craddock, 1972).

The main Ordovician intrusions in the Transantarctic Mountains have been broadly divided

into two groups (Grikurov et al., in press): an earlier group of predominantly dioritic rocks with abundant gabbroic xenoliths in the marginal parts, and a later group of plutonic and hypabyssal intrusions of granitic and granodiorite composition which show cross-cutting relationships to the dioritic group. These two groups include the granitic rocks of northern Victoria Land, the Granite Harbour Intrusive Complex of southern Victoria Land, the Hope Granite in the Beardmore Glacier area, the Queen Maud Batholith in the Queen Maud Mountains, the Wisconsin Range Batholith in the Horlick Mountains and the granitic plutons in the Thiel and Pensacola Mountains. The ages of these rocks, summarized by Elliot (1975, table 9) and determined by various methods on various materials, range from early Silurian to middle Cambrian or earlier but they suggest a mean age of cooling and isotopic closure about lower to middle Ordovician time, e.g. the Hope Granite (Adams, Gabites & Grindley, in press).

Throughout the rest of the craton of Greater Antarctica there are many rocks which have yielded lower Palaeozoic radiometric ages (Picciotto & Coppez, 1963; 1964; Picciotto et al., 1964), indicating a widespread metamorphic episode broadly contemporaneous with the Ross Orogeny. Although some of these ages may represent truly igneous activity, particularly hypabyssal intrusions, the majority are probably more closely related to the metamorphism and are due to isotopic resetting (Soloviev, 1972). In the Sør-Rondane Mountains, Van Autenboer (1969) described granitic, syenitic and gabbroic intrusive rocks of late Cambrian age but several of the radiometric ages (Picciotto & Coppez, 1963; 1964) are Ordovician. Many of the charnockites and enderbites in Enderby Land and the Lambert Glacier region give Ordovician radiometric ages but these are considered to be much older rocks which have undergone isotopic re-equilibration (Trail & MacLeod, 1969a; 1969b).

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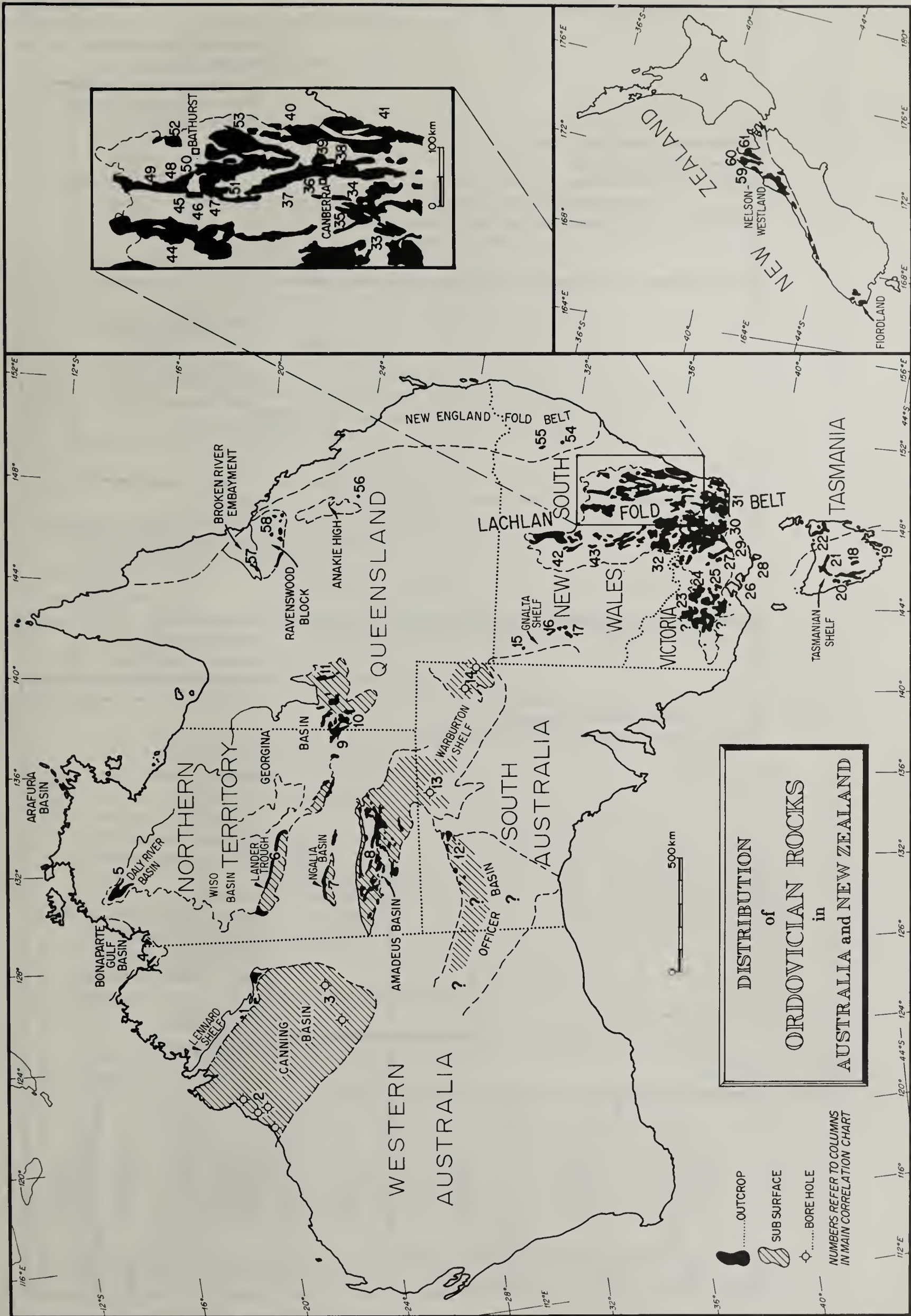


Fig. 1

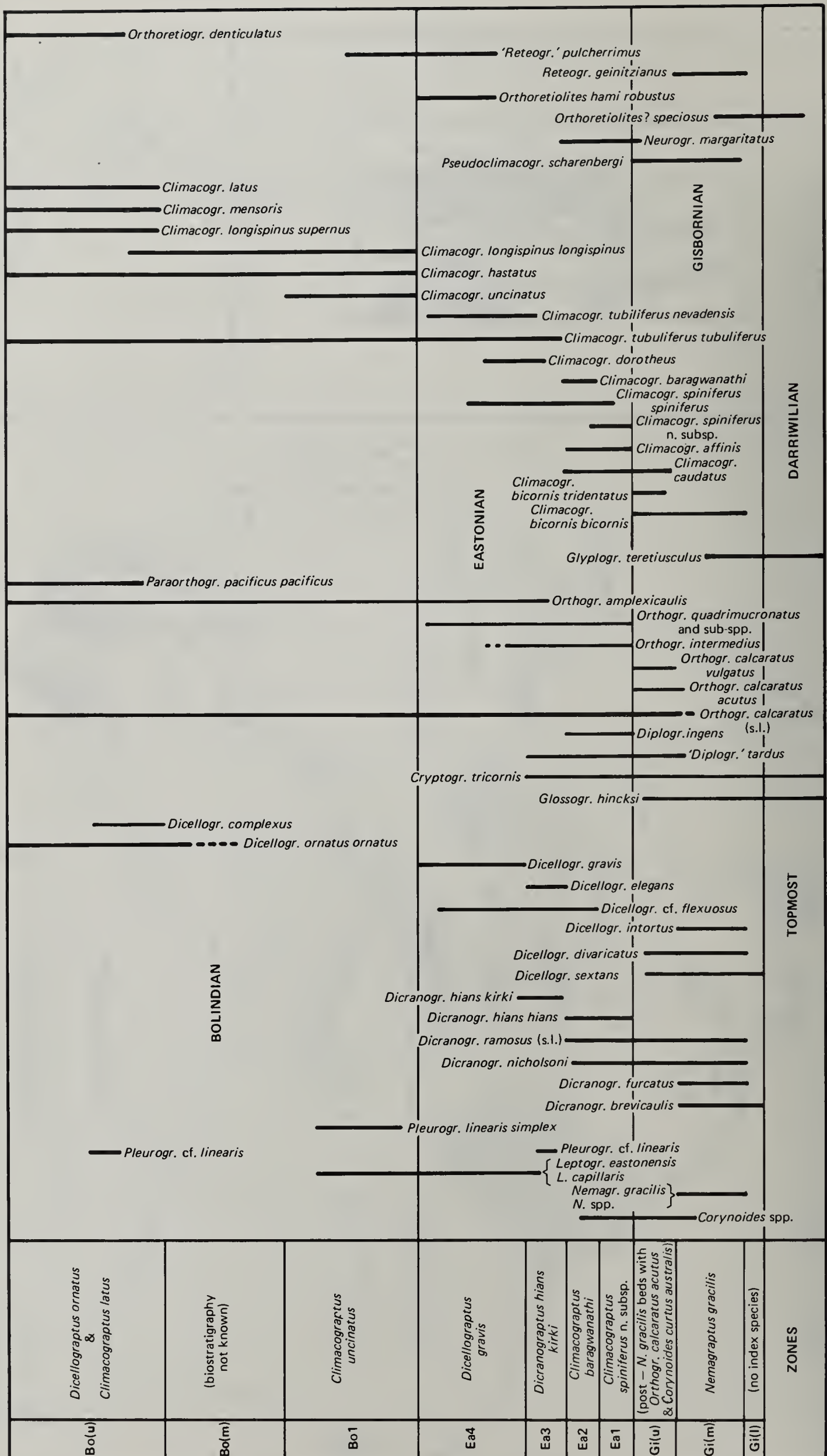
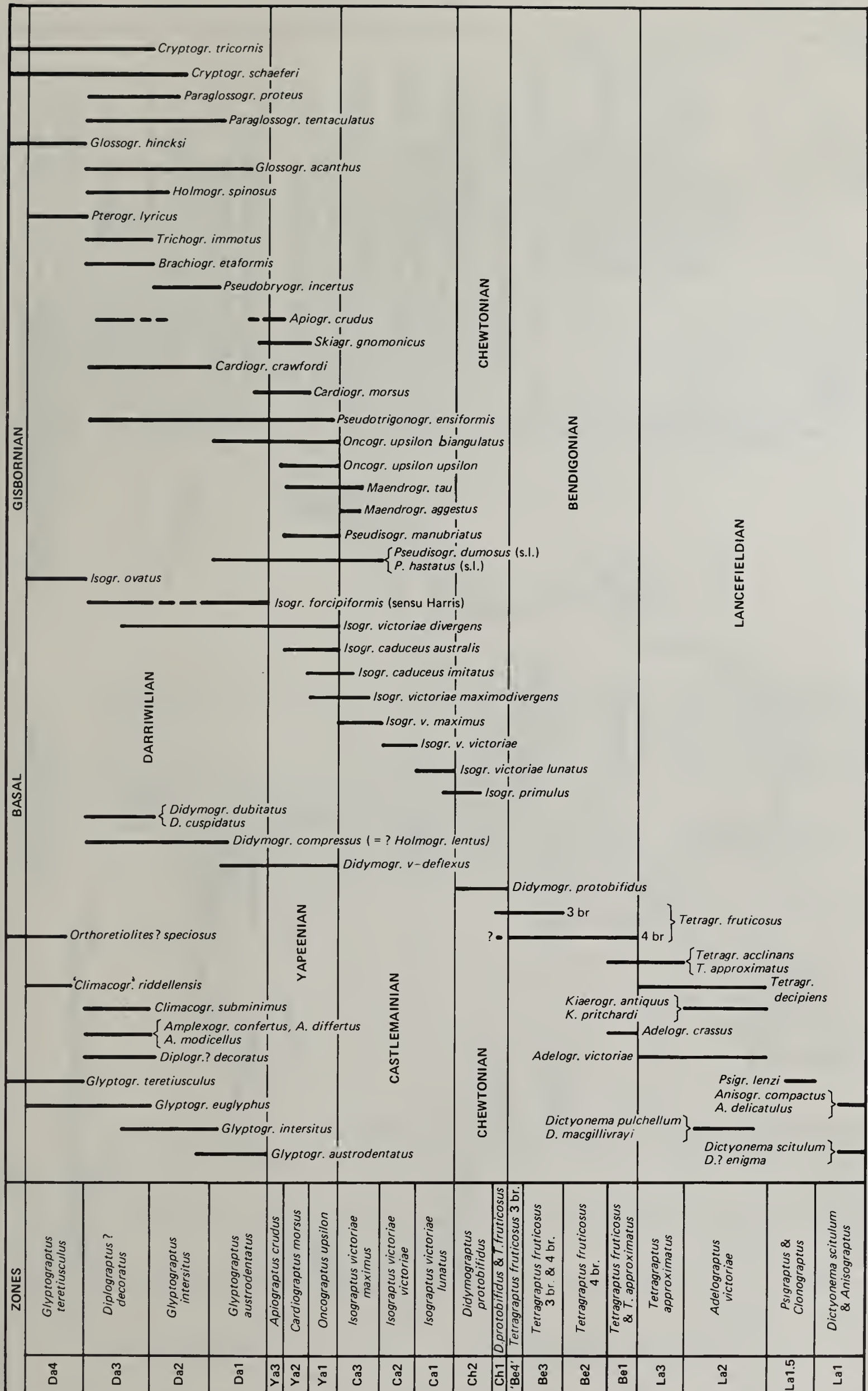
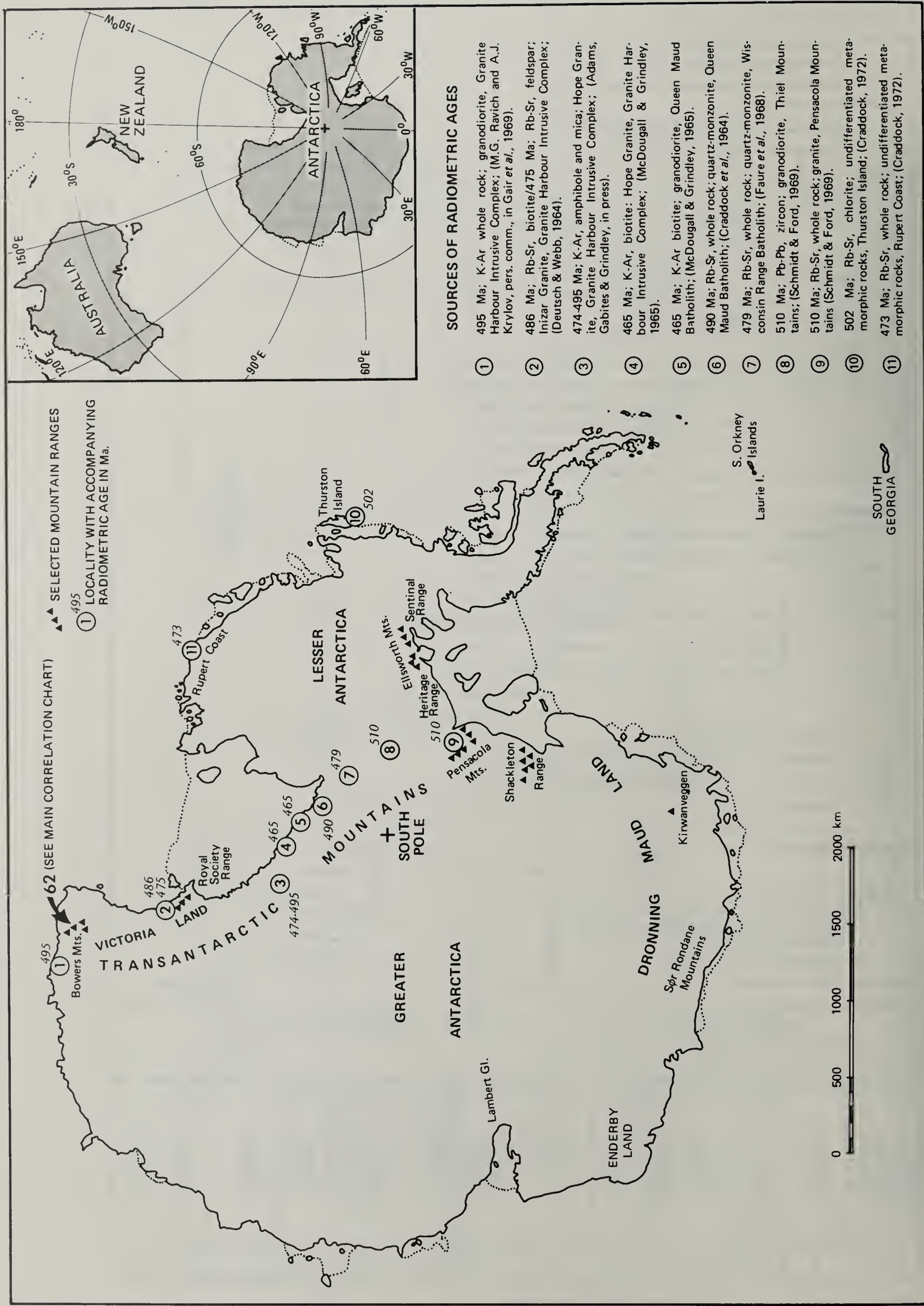


Fig. 2 Chart depicting stratigraphic ranges of key



Victorian graptolites. (Compiled by A.H.M. VandenBerg)



SOURCES OF RADIOMETRIC AGES

- ① 495 Ma; K-Ar whole rock; granodiorite, Granite Harbour Intrusive Complex; (M.G. Ravich and A.J. Krylov, pers. comm., in Gair *et al.*, 1969).
- ② 486 Ma; Rb-Sr, biotite/475 Ma; Rb-Sr, feldspar; Inizar Granite, Granite Harbour Intrusive Complex; (Deutsch & Webb, 1964).
- ③ 474-495 Ma; K-Ar, amphibole and mica; Hope Granite, Granite Harbour Intrusive Complex; (Adams, Gabites & Grindley, in press).
- ④ 465 Ma; K-Ar, biotite; Hope Granite, Granite Harbour Intrusive Complex; (McDougall & Grindley, 1965).
- ⑤ 465 Ma; K-Ar biotite; granodiorite, Queen Maud Batholith; (McDougall & Grindley, 1965).
- ⑥ 490 Ma; Rb-Sr, whole rock; quartz-monzonite, Queen Maud Batholith; (Craddock *et al.*, 1964).
- ⑦ 479 Ma; Rb-Sr, whole rock; quartz-monzonite, Wisconsin Range Batholith; (Faure *et al.*, 1968).
- ⑧ 510 Ma; Pb-Pb, zircon; granodiorite, Thiel Mountains; (Schmidt & Ford, 1969).
- ⑨ 510 Ma; Rb-Sr, whole rock; granite, Pensacola Mountains (Schmidt & Ford, 1969).
- ⑩ 502 Ma; Rb-Sr, chlorite; undifferentiated metamorphic rocks, Thurston Island; (Craddock, 1972).
- ⑪ 473 Ma; Rb-Sr, whole rock; undifferentiated metamorphic rocks, Rupert Coast; (Craddock, 1972).

Fig. 3 Sketch map of Antarctica showing main localities and selected radiometric ages of intrusions.

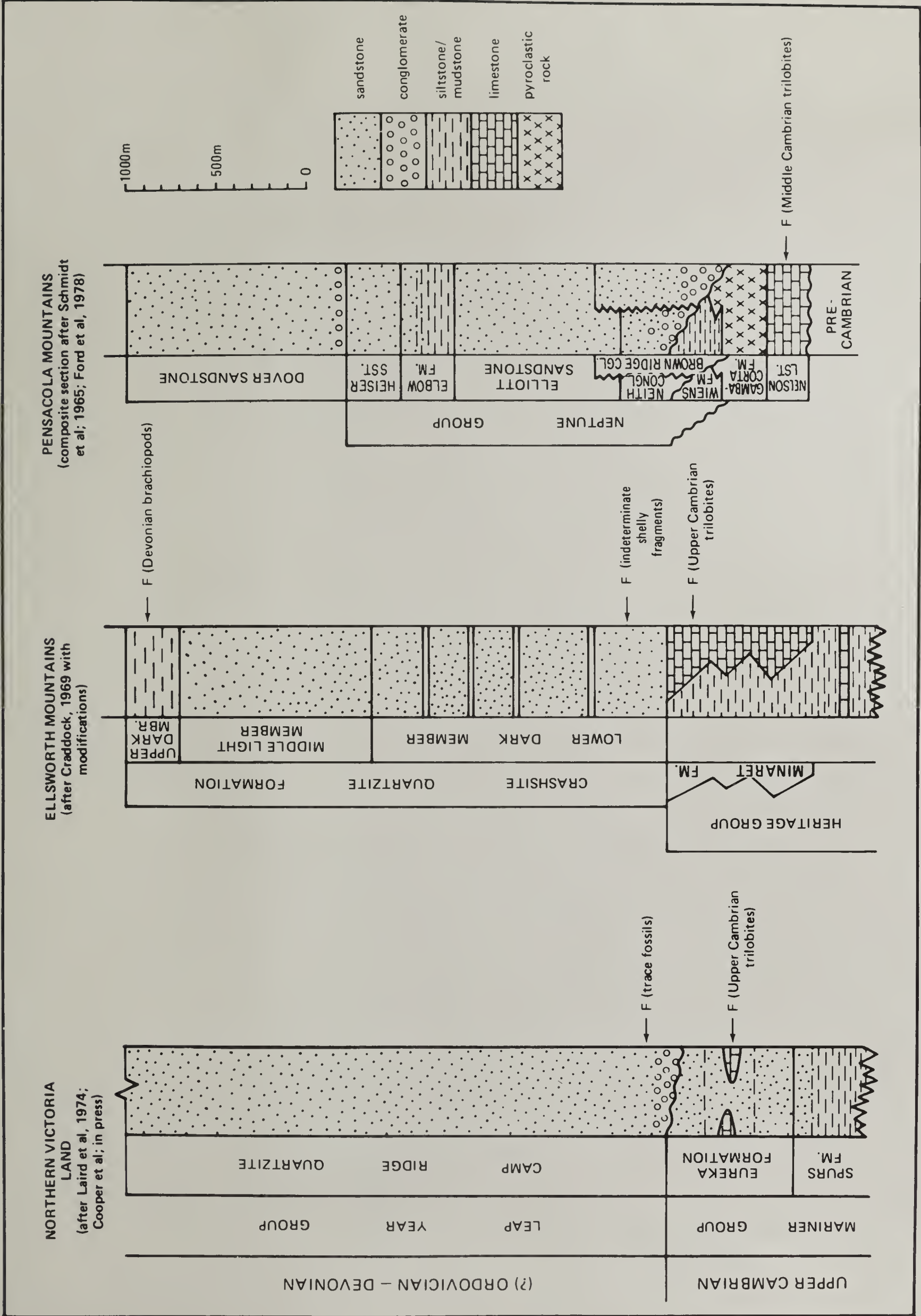
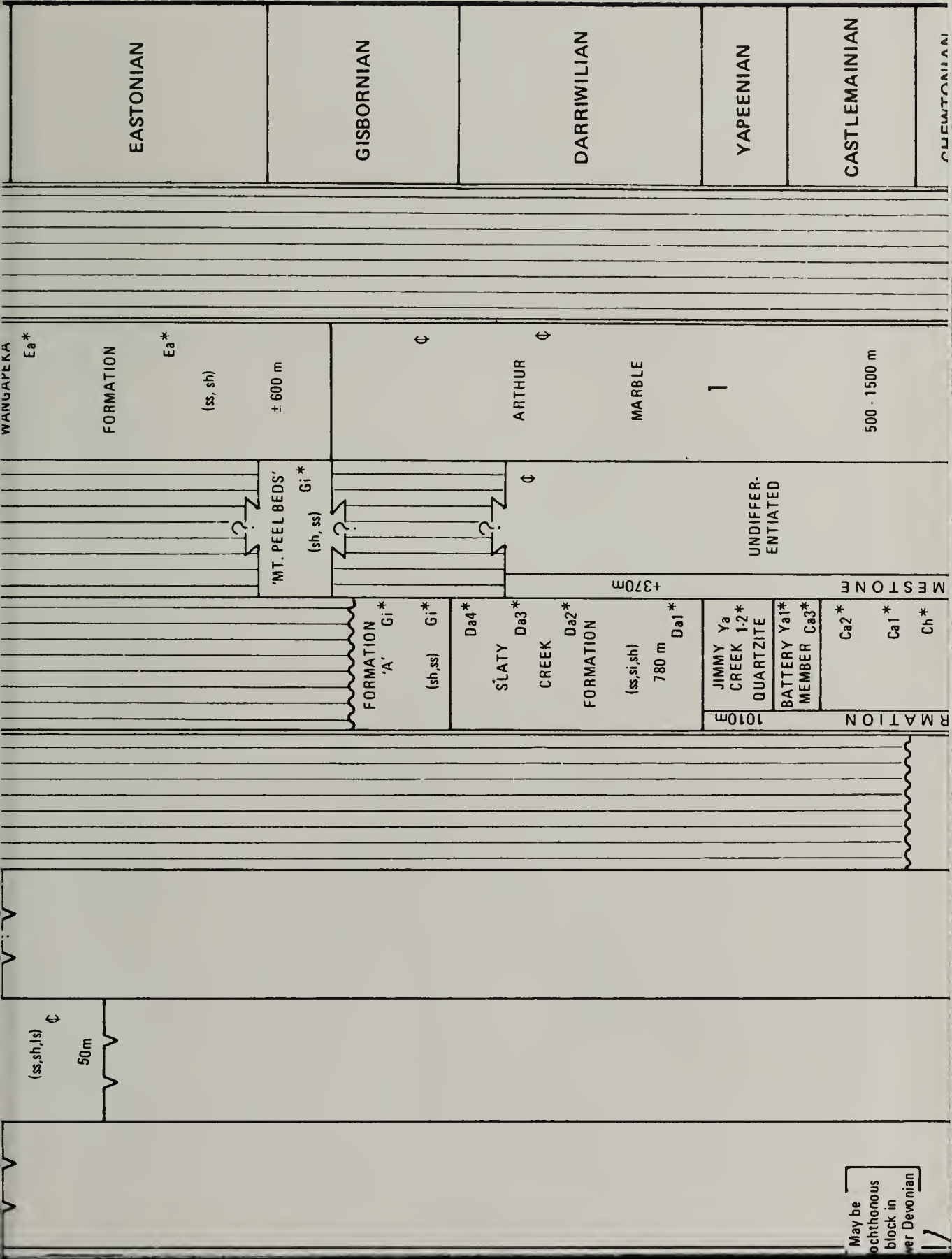
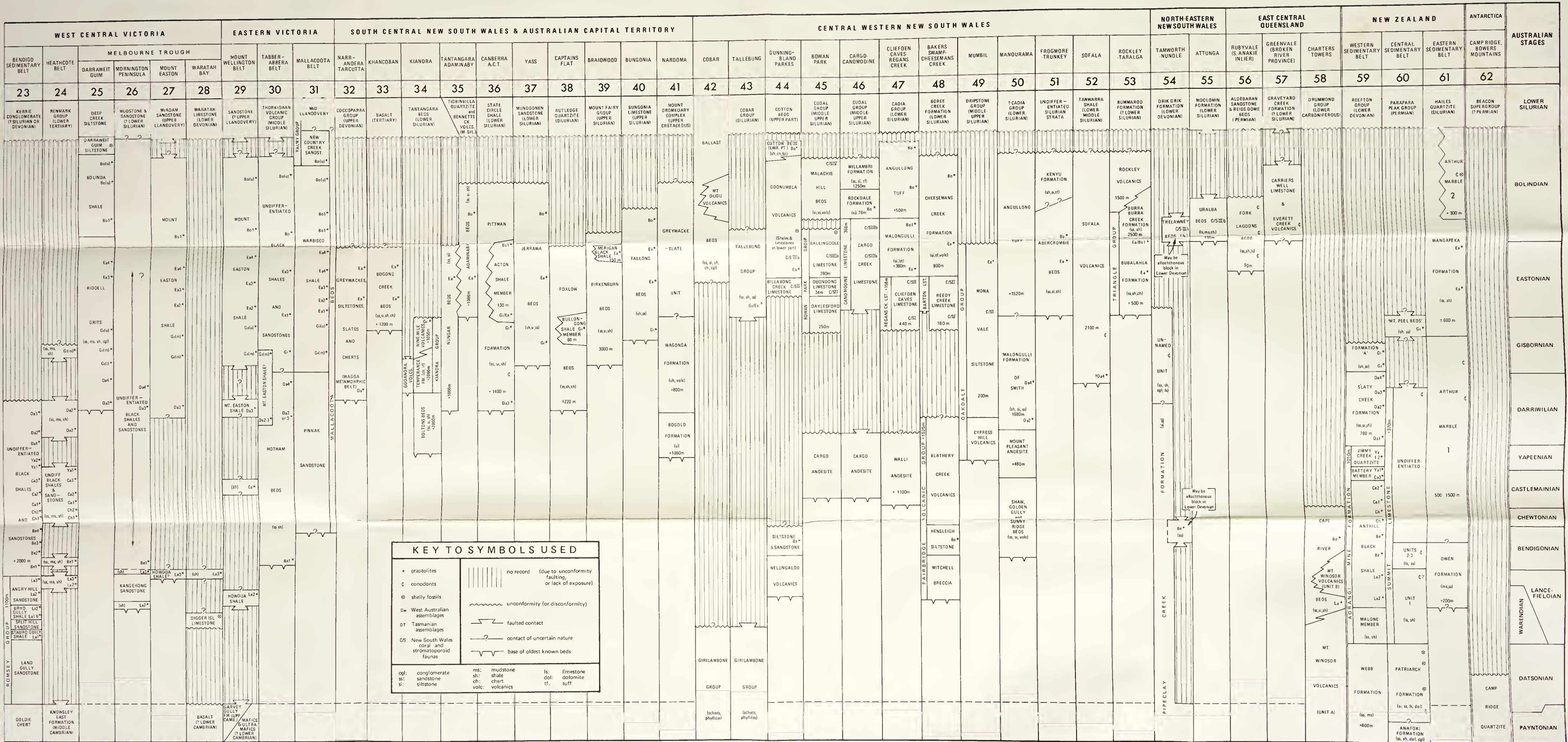
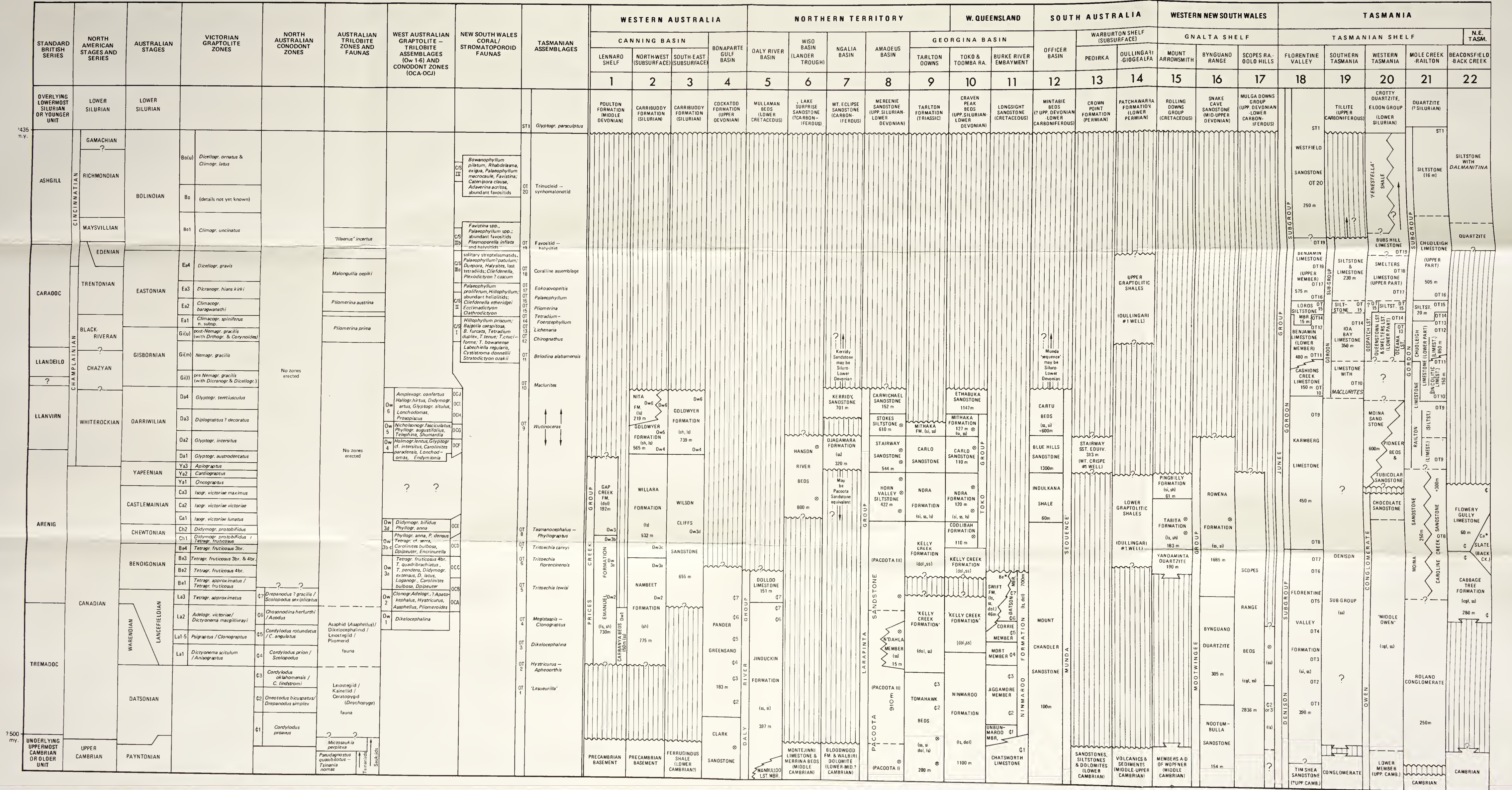


Fig. 4 Representatives of three stratigraphic sections in Antarctica which may include deposits of Ordovician age.





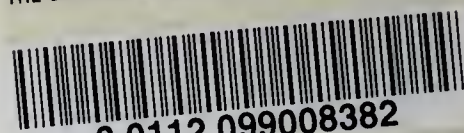
WESTERN NEW SOUTH WALES				TASMANIA				
GNALTA SHELF				TASMANIAN SHELF				N.E. TASM.
MOUNT ARROWSMITH	BYNGUANO RANGE	SCOPES RA.-DOLO HILLS	FLORENTINE VALLEY	SOUTHERN TASMANIA	WESTERN TASMANIA	MOLE CREEK -RAILTON	BEACONSFIELD -BACK CREEK	
15	16	17	18	19	20	21	22	
ROLLING OOWNS GROUP (CRETACEOUS)	SNAKE CAVE SANDSTONE (MID-UPPER DEVONIAN)	MULGA OOWNS GROUP (UPP. DEVONIAN -LOWER CARBON-IFEROUS)	ST1 WESTFIELD SANDSTONE OT 20 250 m	TILLITE (UPPER CARBONIFEROUS)	CROTTY QUARTZITE, ELOON GROUP (LOWER SILURIAN)	QUARTZITE (? SILURIAN)		SILTSTONE WITH DALMANITINA
			SUB-GROUP		ST1		SILTSTONE (16 m)	QUARTZITE
								CHUDLEIGH



CORRELATION CHART FOR THE ORDOVICIAN SYSTEM



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